



Georgian Bay
Storm Gathering

How the Weather Works - and how to forecast for it...

**Ron Bianchi –
Meteorologist/Sailor**

Earth's Atmosphere



99% of atmospheric gases, including water vapor, extend only 30 kilometer (km) above earth's surface.

Most of our weather, however, occurs within the first 10 to 15 km.²



NASA

Atmospheric Gases

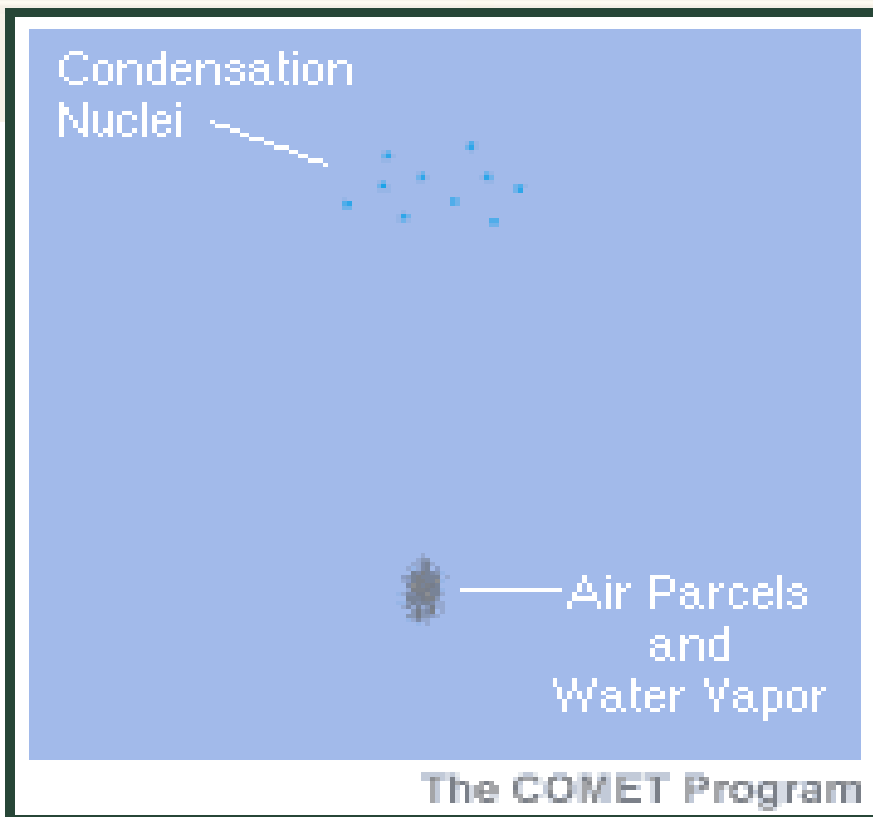
Table 1.1 Composition of the Atmosphere Near the Earth's Surface

PERMANENT GASES			VARIABLE GASES			
Gas	Symbol	Percent (by Volume) Dry Air	Gas (and Particles)	Symbol	Percent (by Volume)	Parts per Million (ppm)*
Nitrogen	N ₂	78.08	Water vapor	H ₂ O	0 to 4	
Oxygen	O ₂	20.95	Carbon dioxide	CO ₂	0.037	374*
Argon	Ar	0.93	Methane	CH ₄	0.00017	1.7
Neon	Ne	0.0018	Nitrous oxide	N ₂ O	0.00003	0.3
Helium	He	0.0005	Ozone	O ₃	0.000004	0.04†
Hydrogen	H ₂	0.00006	Particles (dust, soot, etc.)		0.000001	0.01–0.15
Xenon	Xe	0.000009	Chlorofluorocarbons (CFCs)		0.0000002	0.0002

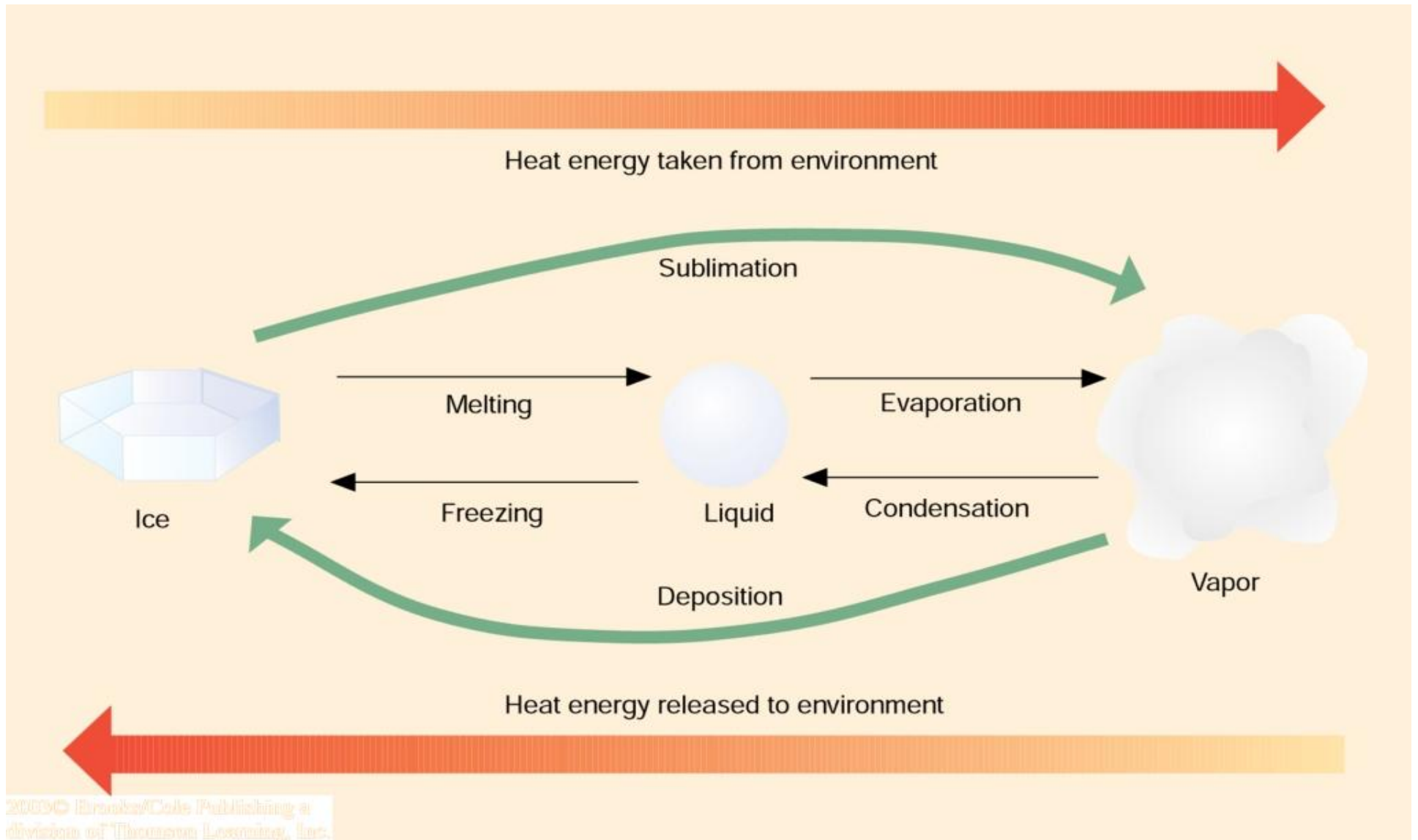
Nitrogen, oxygen, argon, water vapor, carbon dioxide, and most other gases are invisible.

Clouds are not gas, but condensed vapor in the form of liquid droplets.

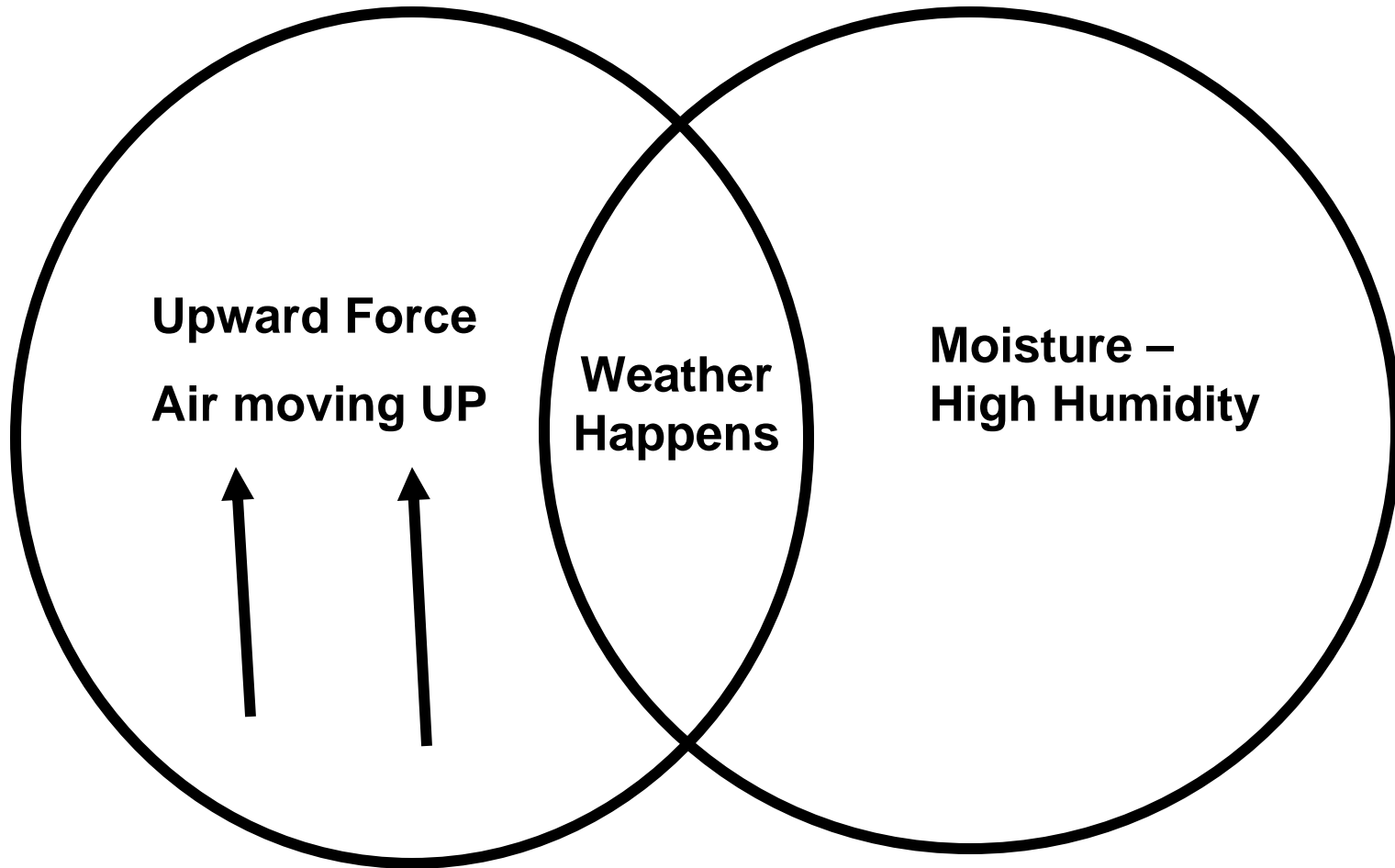
Ground based smog, which is visible, contains reactants of nitrogen and ozone.



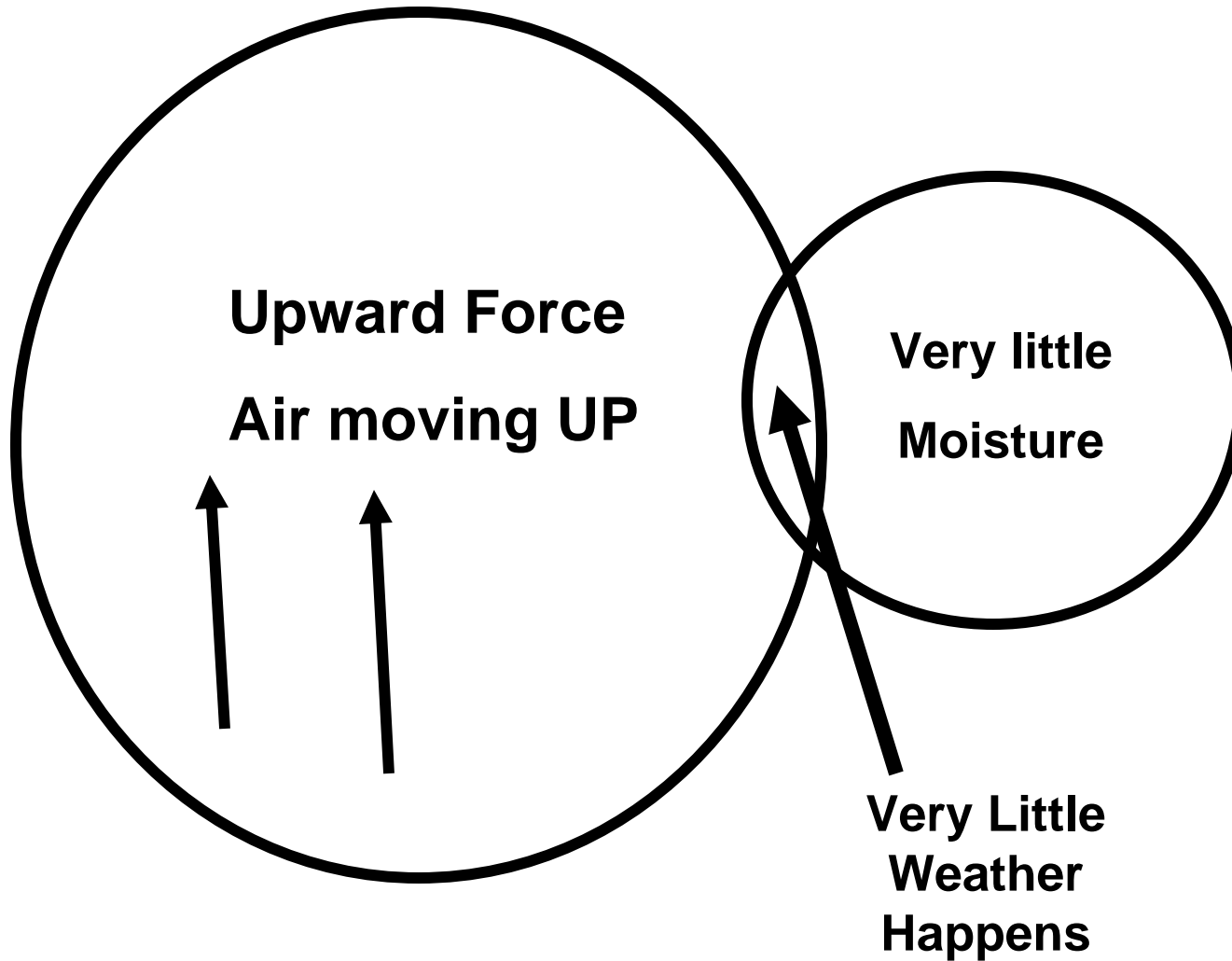
Latent Heat: The Fuel for Weather



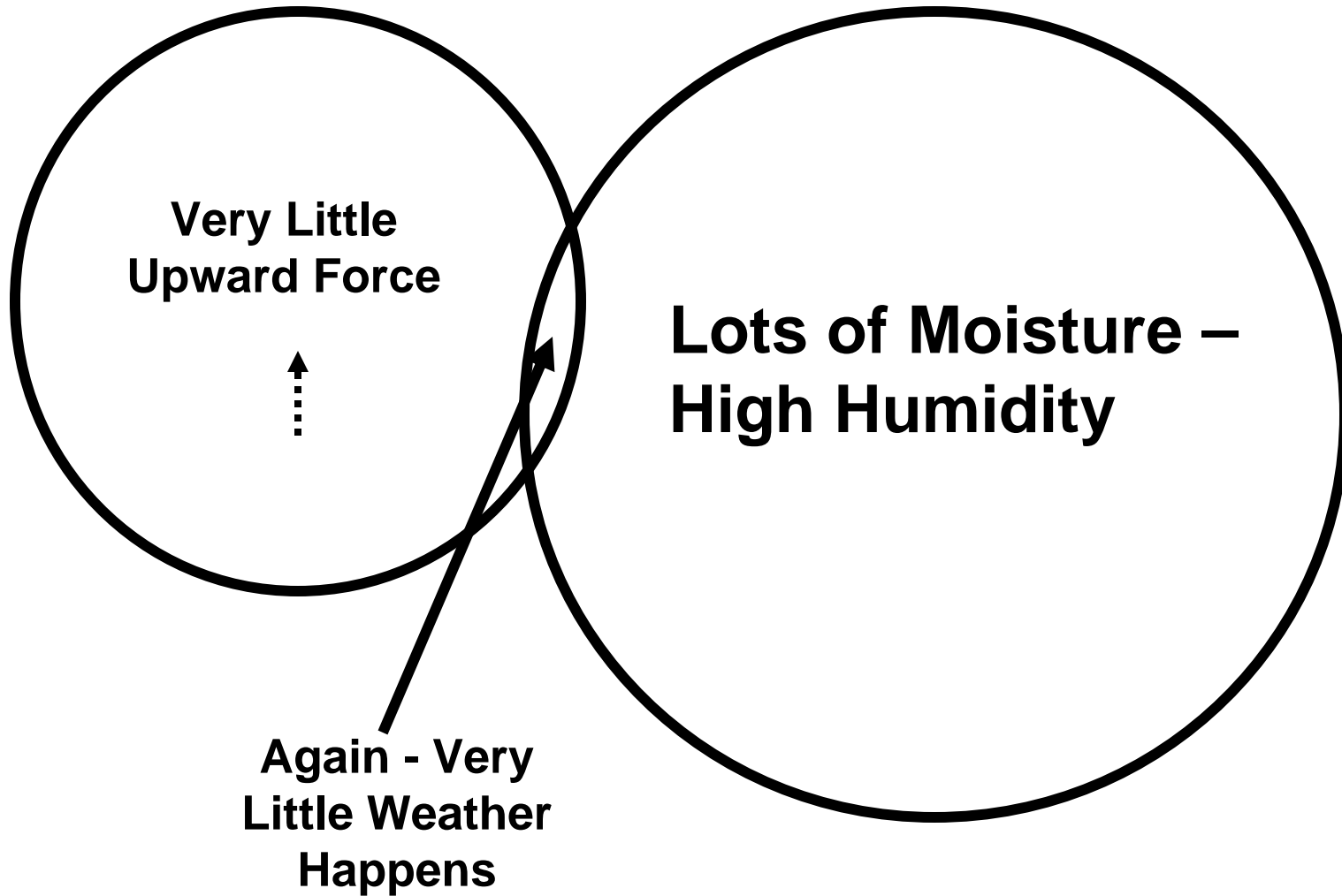
It's that simple, or is it?



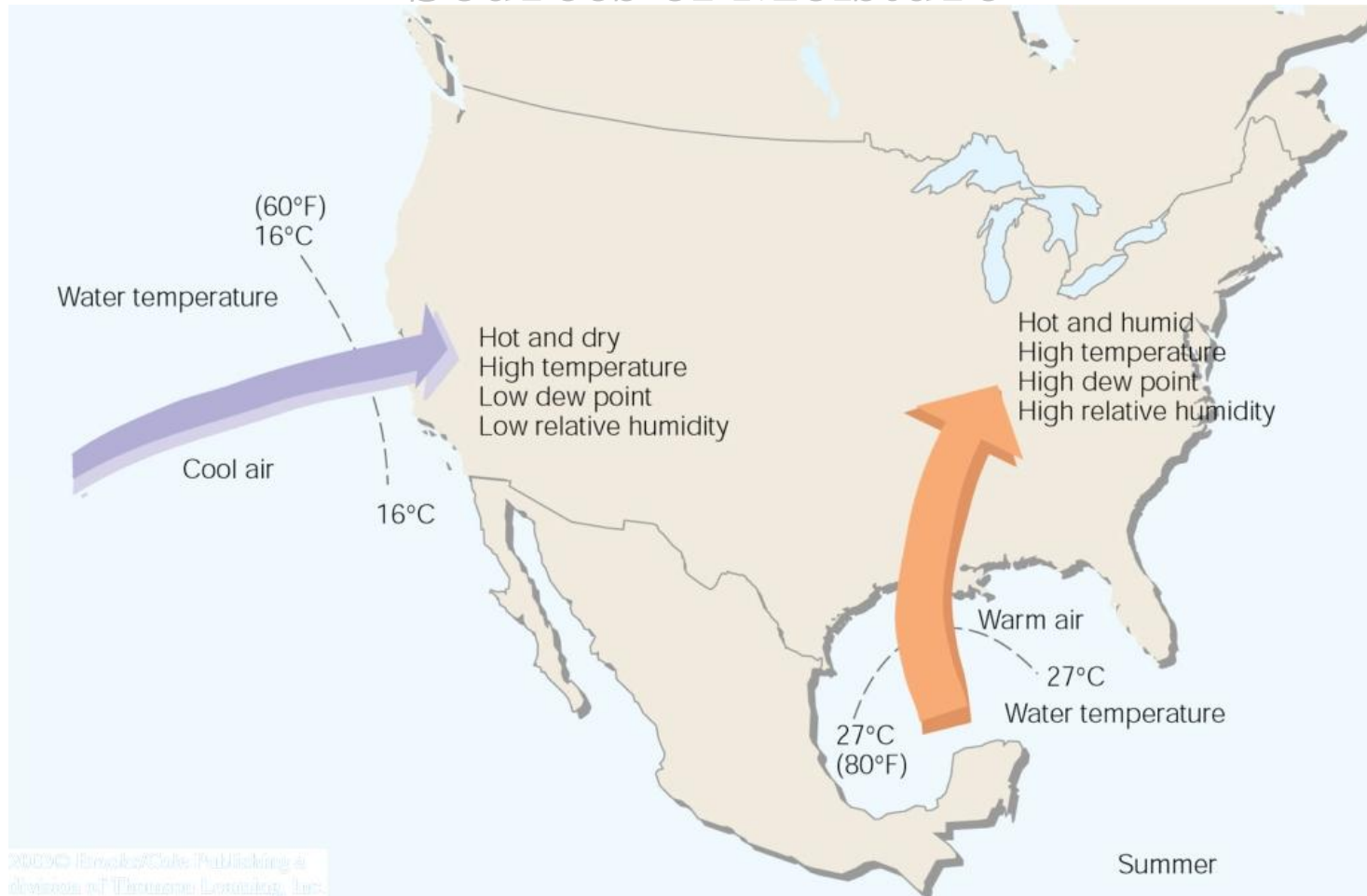
**Good Upward Force + Very Little
Moisture = **Very Little Weather Happens****



**Little Upward Force + Lots of Moisture
= **Very Little Weather Happens****

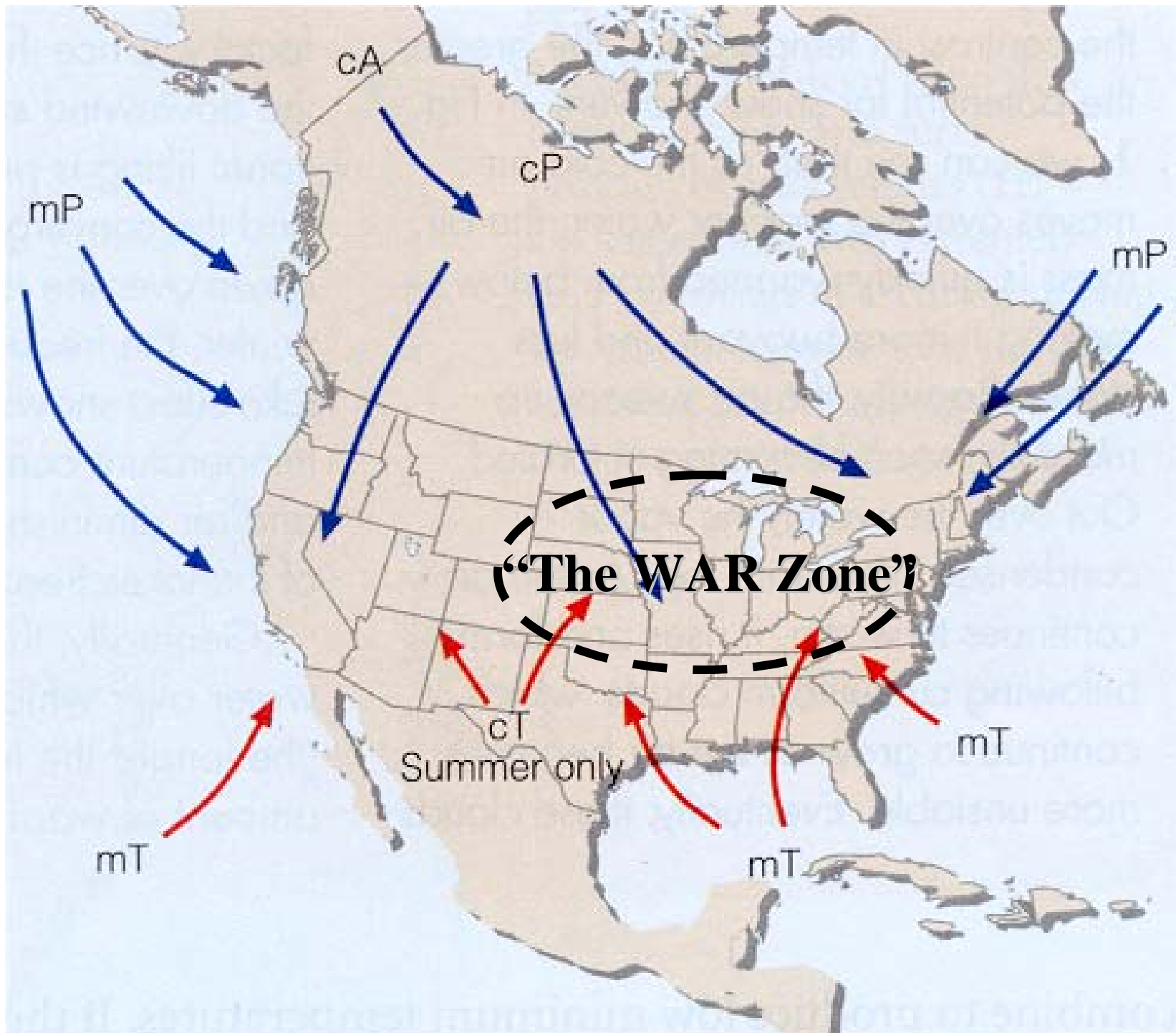


Sources of Moisture

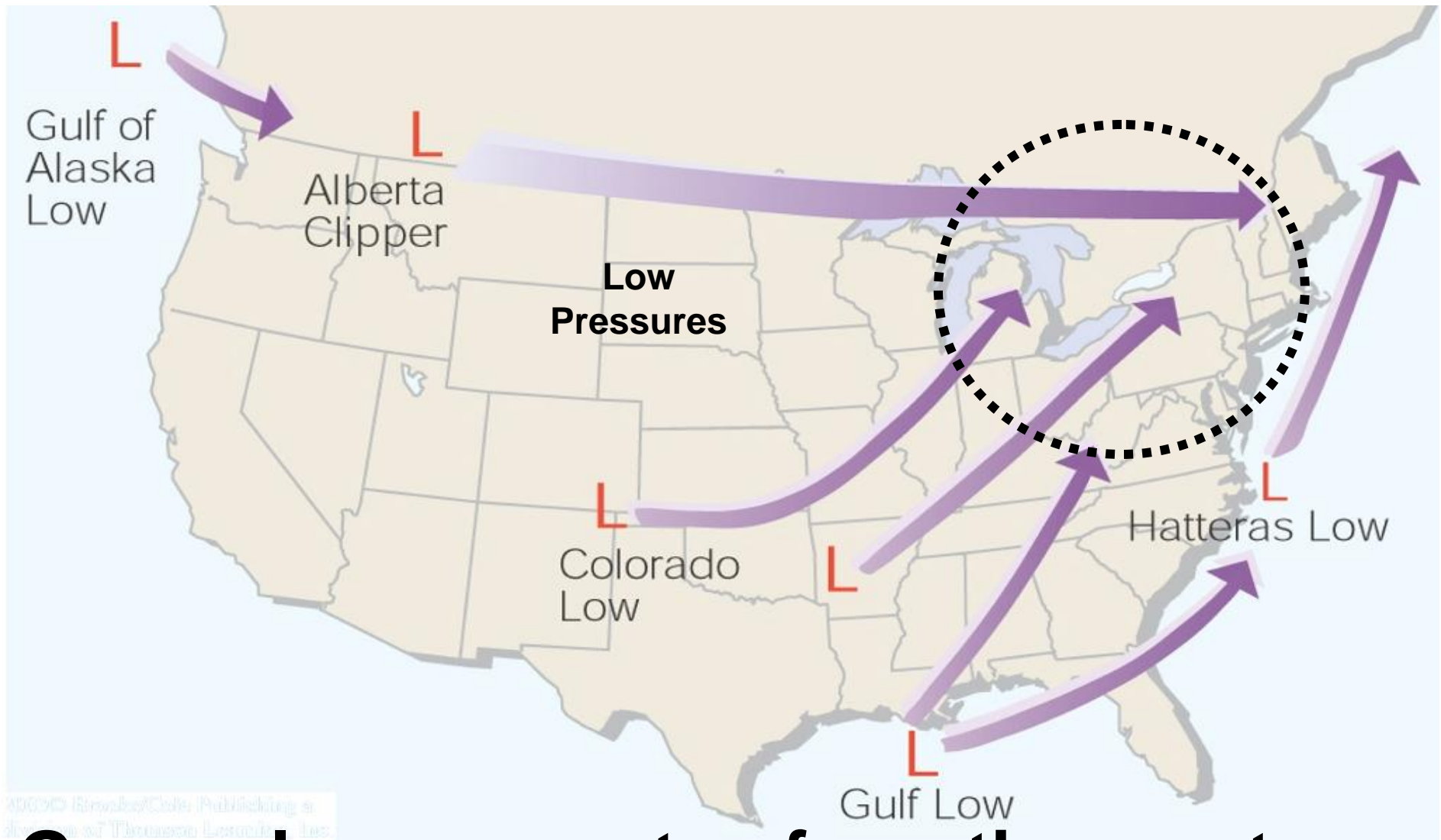


Patterns of humidity are strongly governed by wind direction and ocean temperatures.

Cooler Pacific waters create lower humidities in the west, while warmer Gulf waters generate high humidity along the southeast and east coast.



Storm Paths



General movements of weather systems across the Great Lakes

Who invented the cloud classification system?



← Luke Howard

"the father of meteorology"

Types of Clouds

There are four basic cloud categories observed in our atmosphere:



High-level clouds which form above 20,000 feet (6,000 m) and are usually composed of ice crystals. High-level clouds are typically thin and white in appearance.



Nimbus comes from the Latin word meaning "**rain**". These clouds typically form between 7,000 and 15,000 feet (2,100 to 4,600 m) and bring steady precipitation.

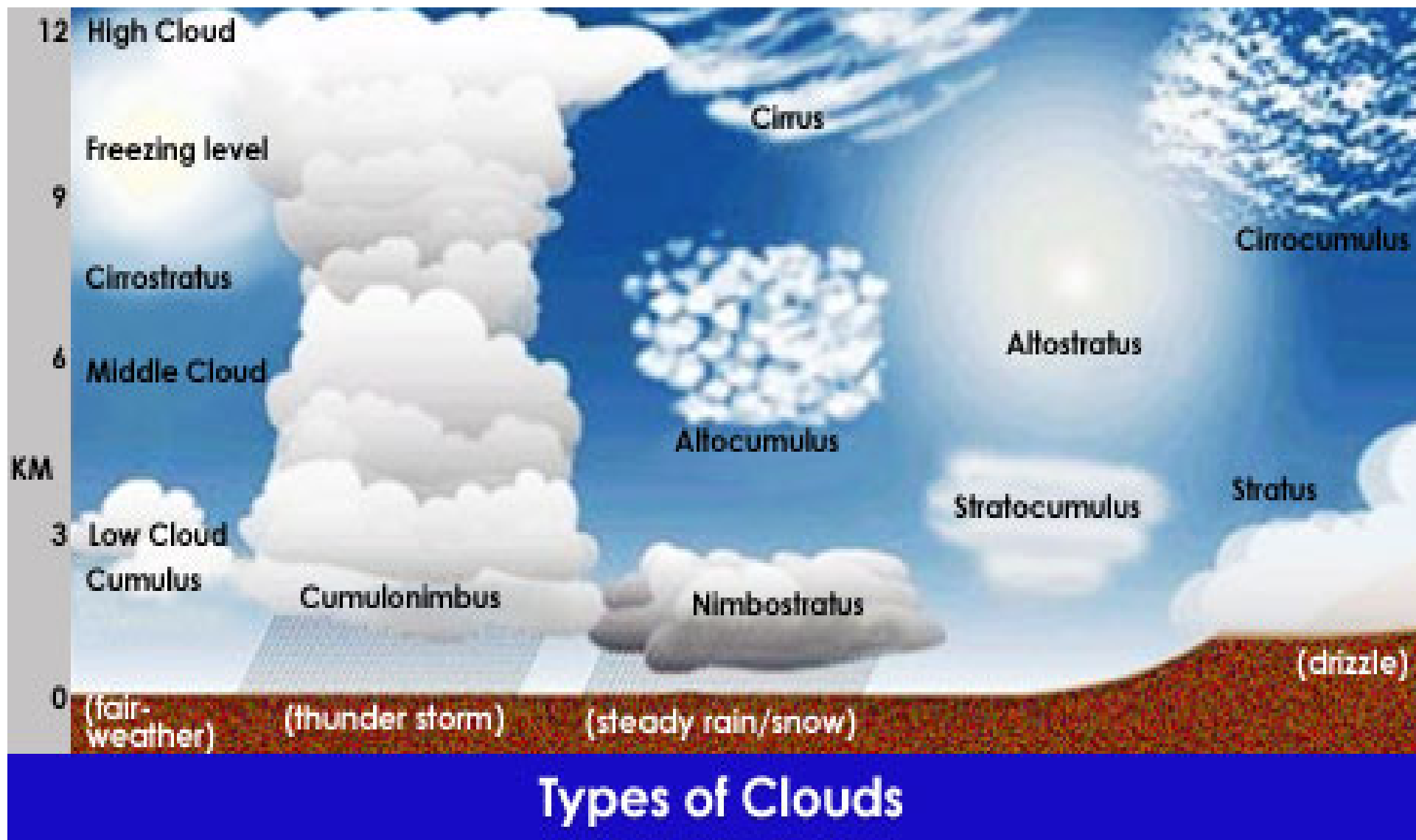


Clouds look like white fluffy cotton balls or **heaps** and show the vertical motion or thermal uplift of air taking place in the atmosphere. The start of a thunderstorm.



Stratus" is Latin for **layer** or blanket. The clouds consist of a feature-less low layer that can cover the entire sky like a blanket, bringing generally gray and dull weather.

“The Entire Cloud Family”





Cirrus



Cumulus



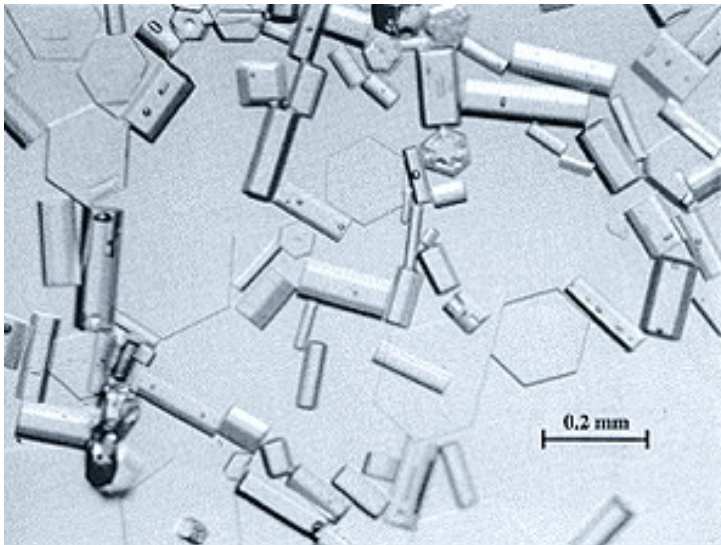
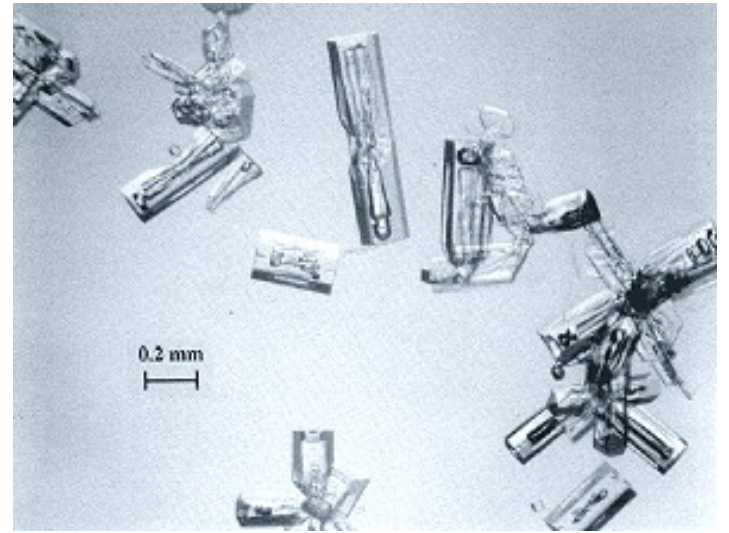
Stratus



High-Level Clouds

- High-level clouds form above 20,000 feet (6,000 meters)
- Made up of all Ice Crystals





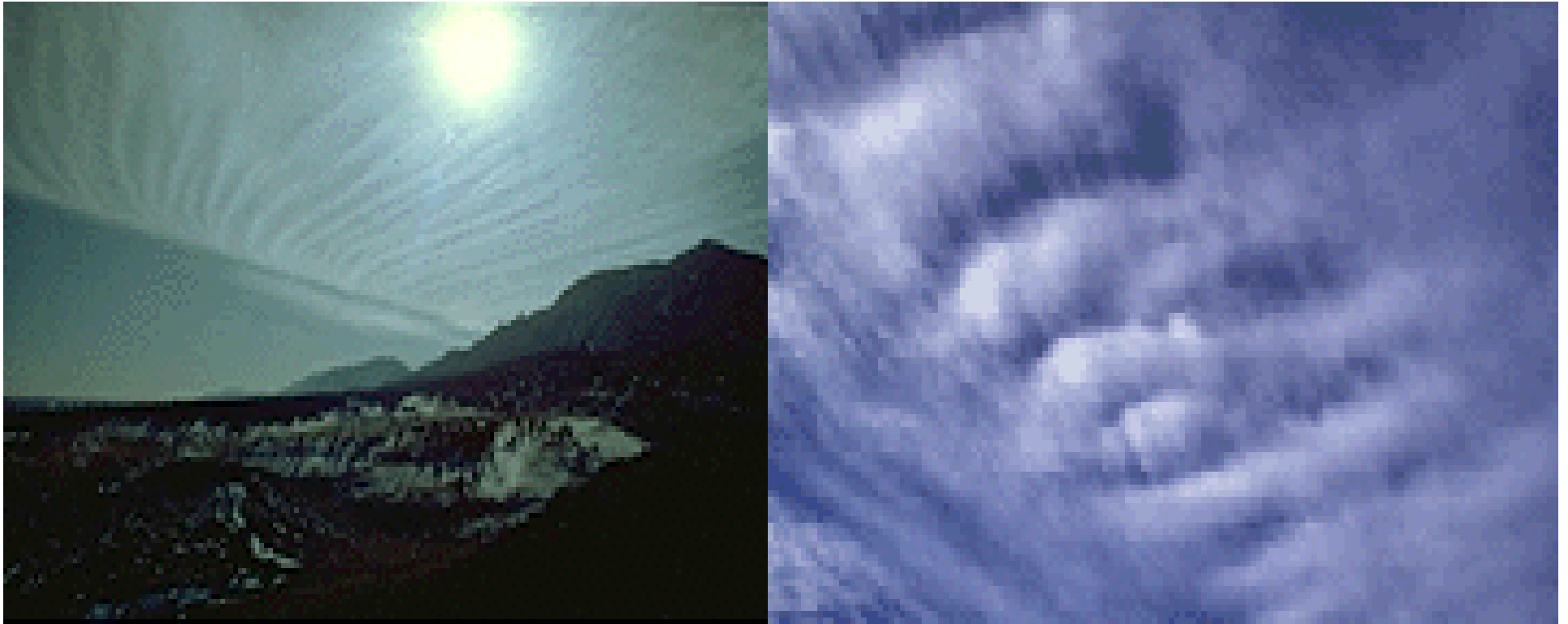




So what does it tell the Mariner – changes such as a warming trend, clouds and rain is a short ~24 hours away.

- So enjoy you day out on the water





Cirrostratus Clouds

sheet-like and nearly transparent
Weather Change is ~24 hrs away

Cirrostratus Clouds

High clouds that thinly cover the entire sky with ice crystals.

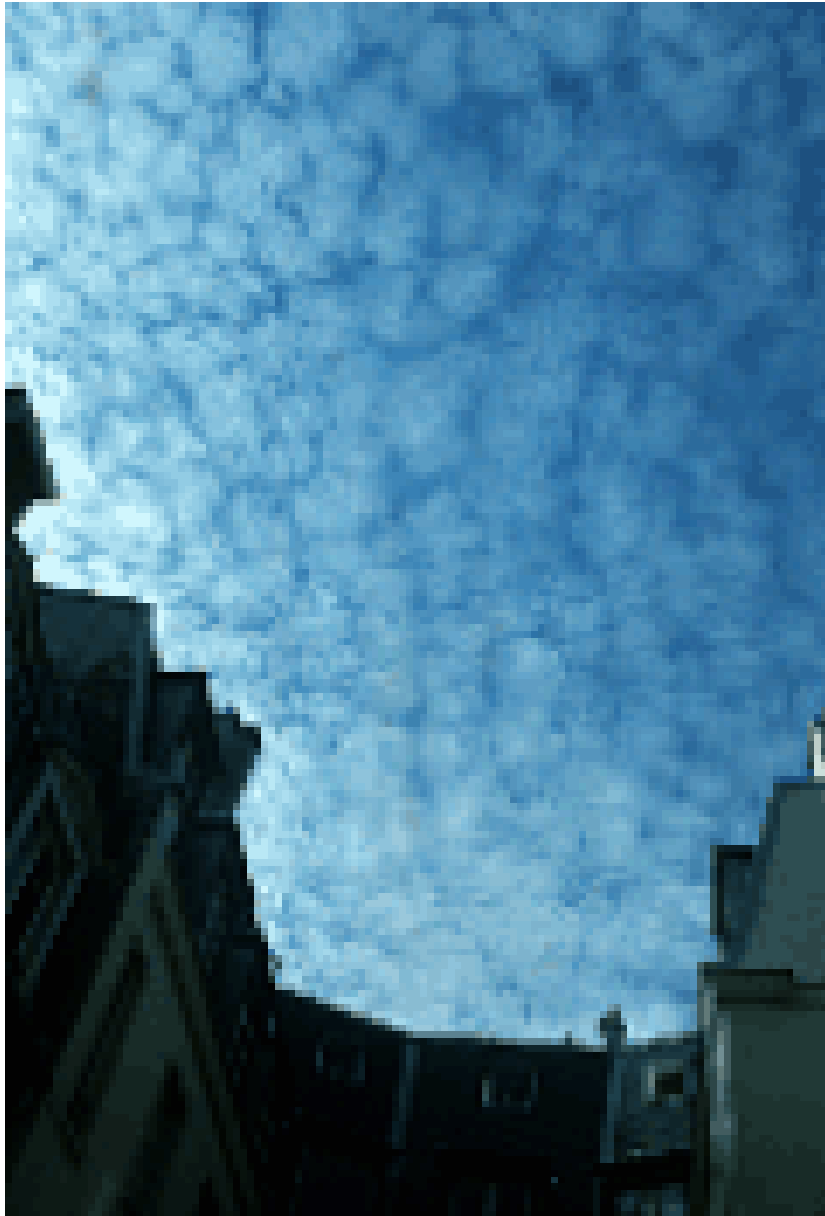
Light passing through these crystals may form a halo.



Cirrocumulus Clouds



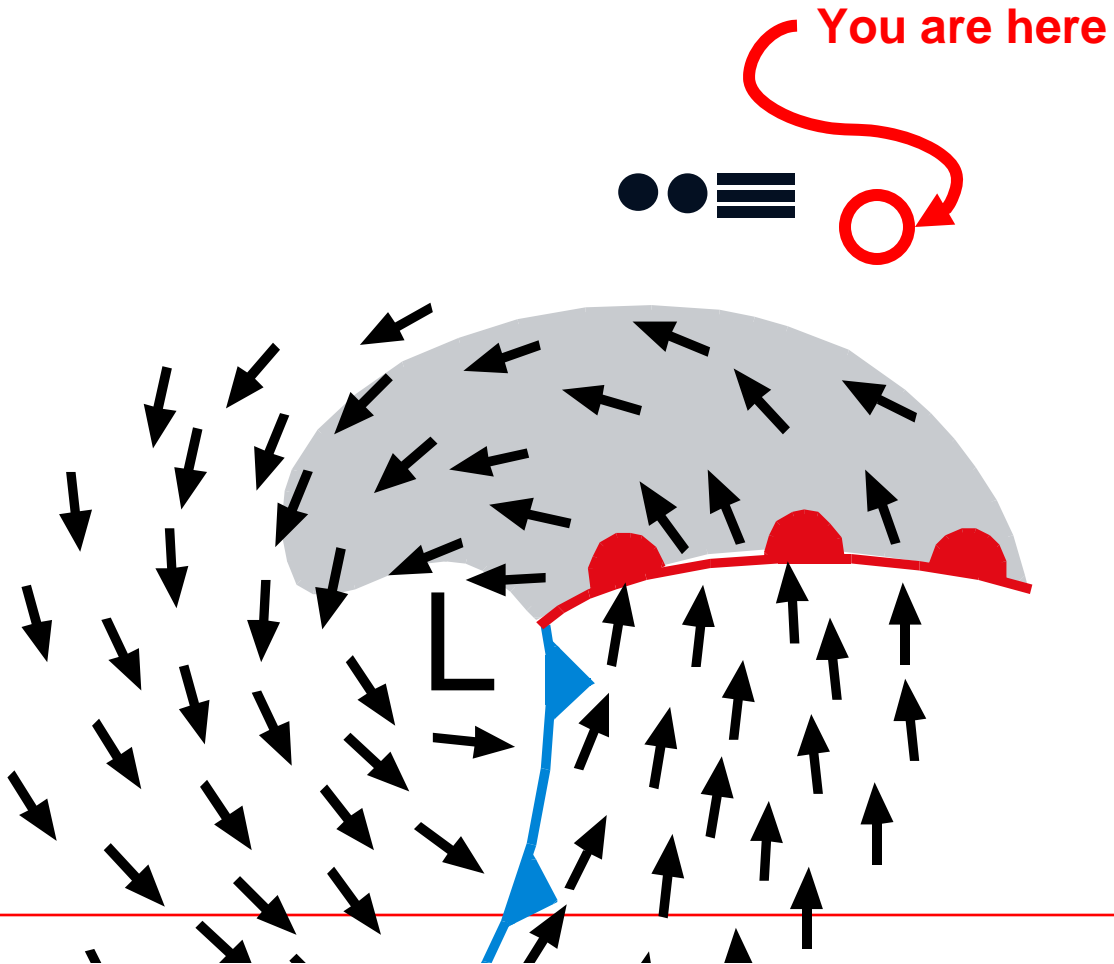
High clouds that are rounded puffs, possibly in rows, are less common than cirrus.

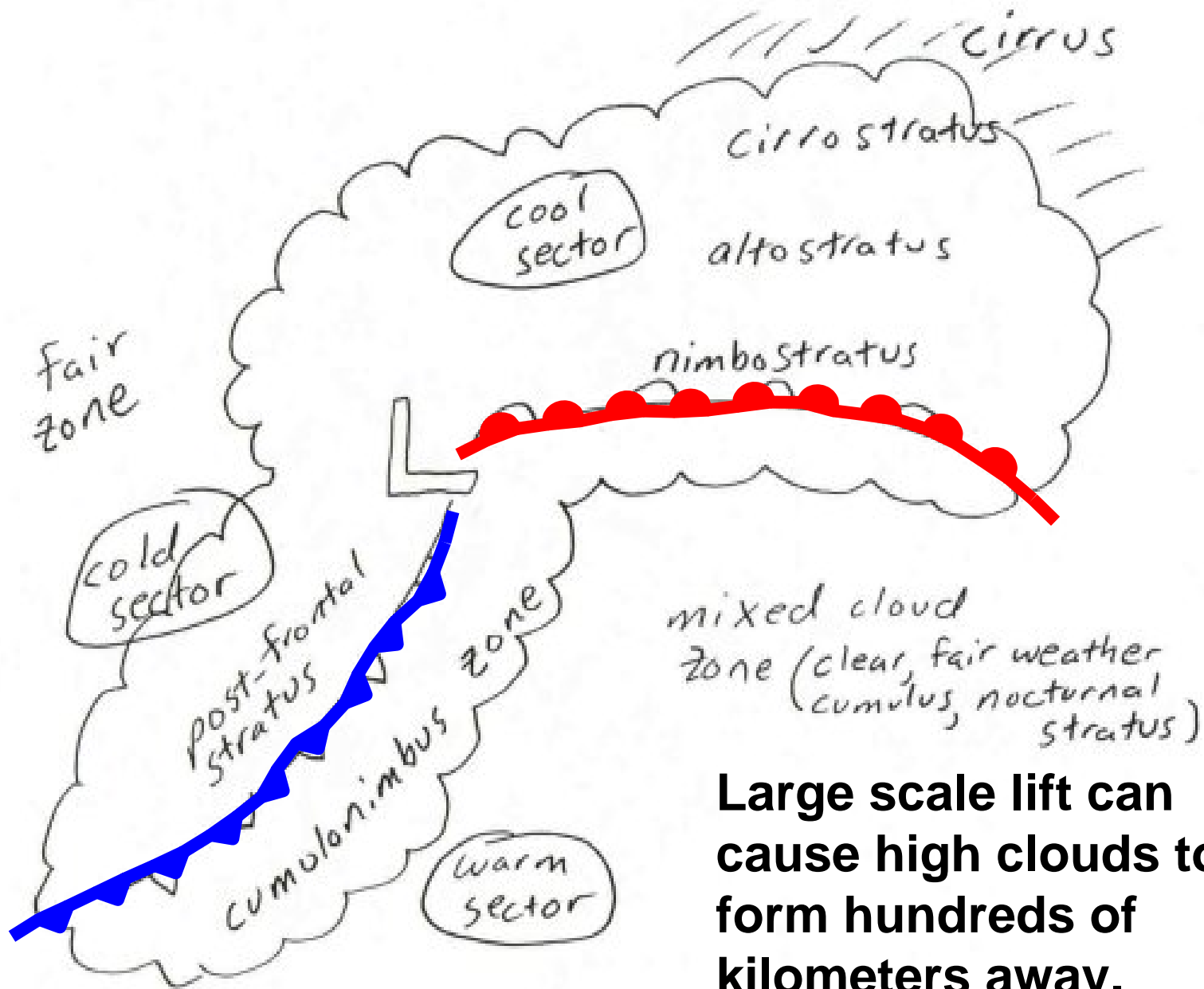


Cirrocumulus clouds
Small, rounded white puffs.
small ripples in the cirrocumulus
resemble the scales of a fish.
"mackerel sky."



Again Change is ~24 hrs away

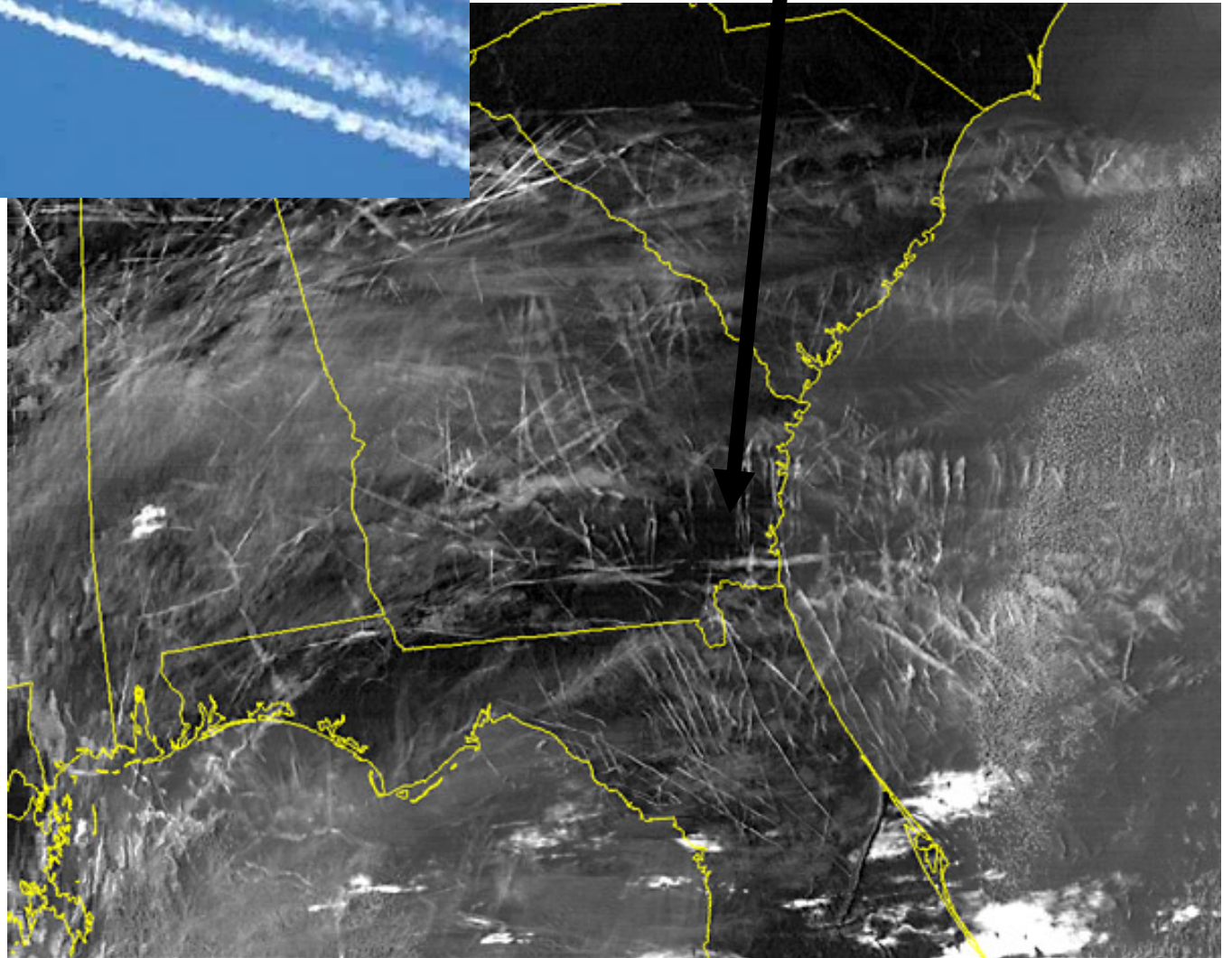
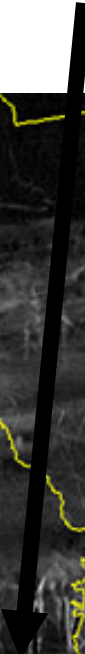




Large scale lift can cause high clouds to form hundreds of kilometers away.

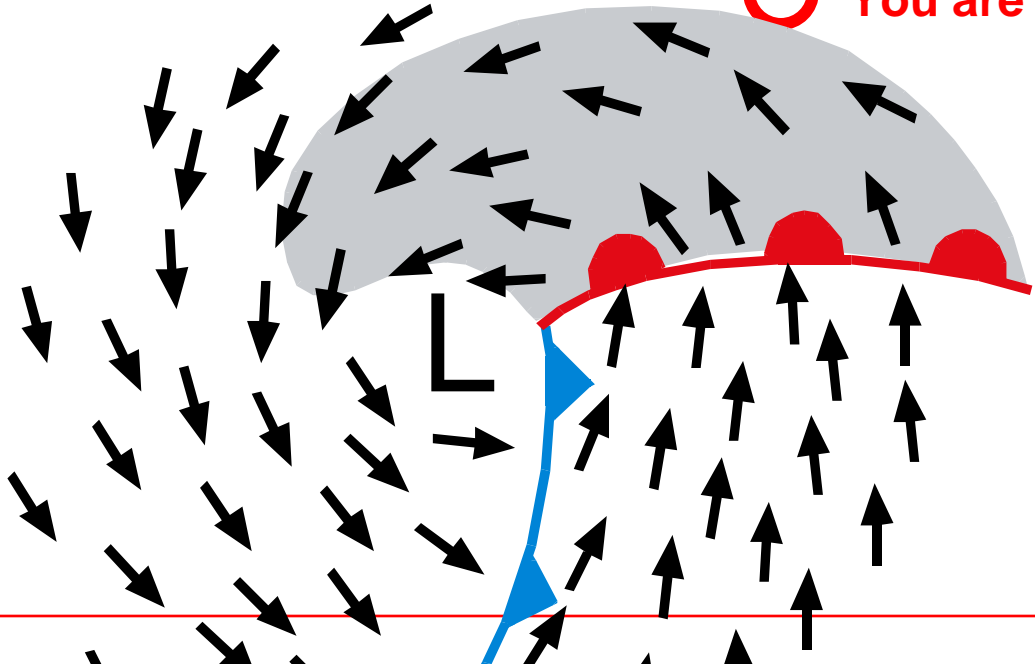


**What are
these????**





You are here



Mid-Level Clouds The next step
down... "Alto" Clouds

Clouds with the prefix "alto"
bases between 2000 and 7000 m
(6500 to 23,000 ft.)

They follow the high Clouds.



Altostratus Clouds



Alto cumulus

Bumpy look

- Indicates unstable air approaching

Weather Change is now ~12-18 hrs away



Low-level Clouds - The last step down.... STRATUS CLOUDS

Low clouds are of mostly composed of water droplets since their bases generally lie below 6,500 feet (2,000 meters).

Weather change is underway, or has just happened



-- Photograph by Ronald L. Holle --
-- U. of Illinois Cloud Catalog --

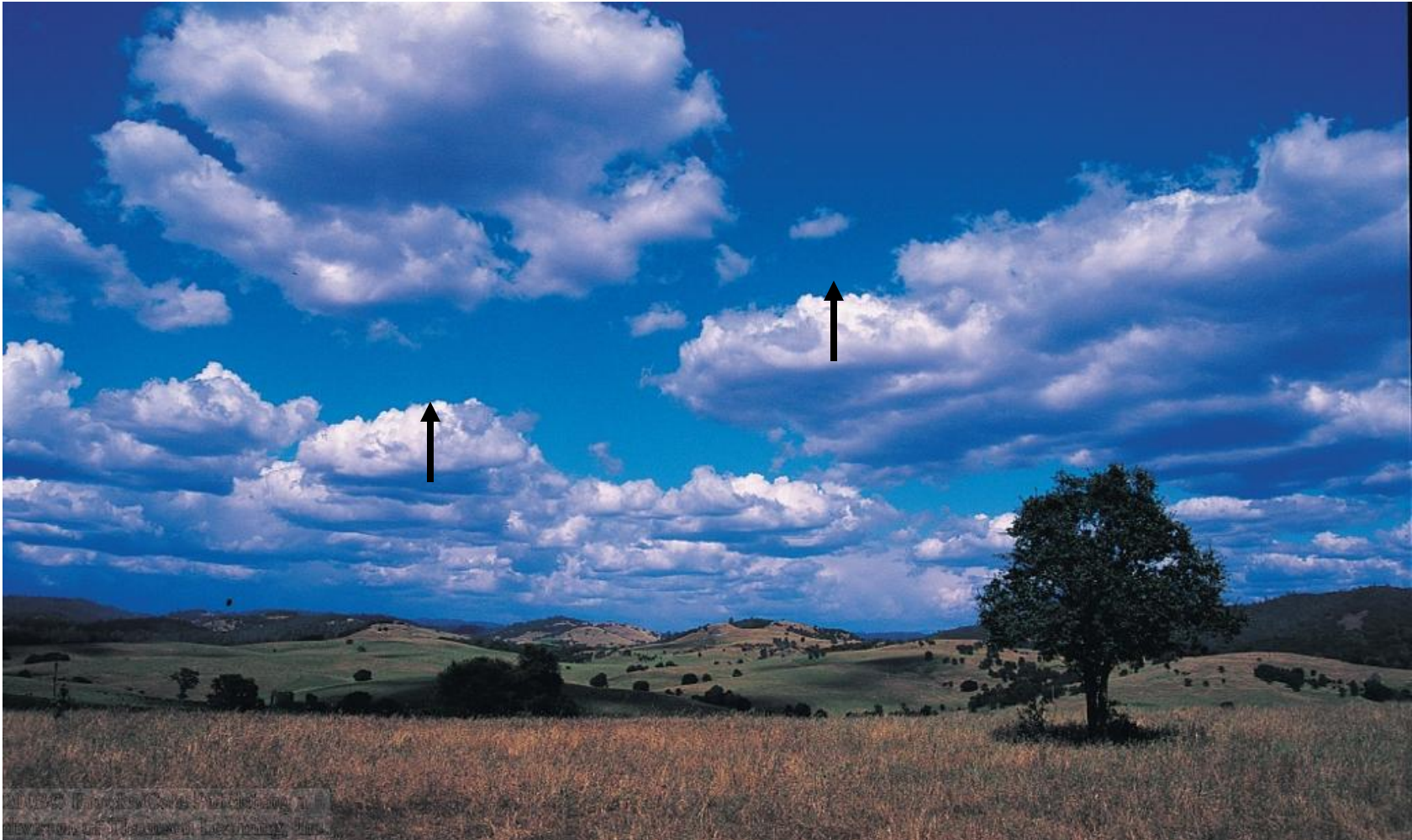


Stratocumulus.....

If these Cumulus do not change height in 3-5 hrs then fair weather continues

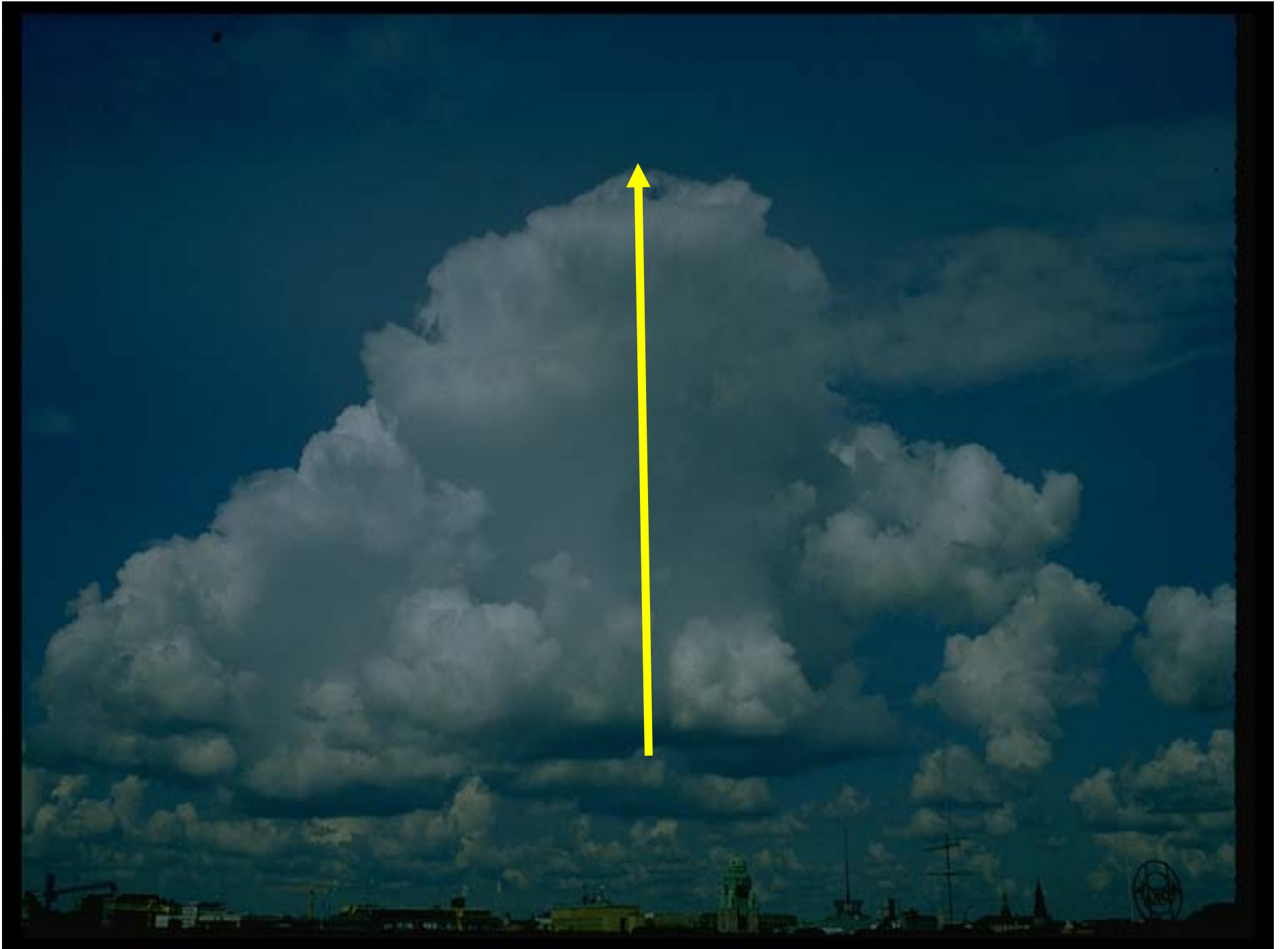


Cumulus Humilis Clouds



Clouds with vertical development that take a variety of shapes, separated by sinking air and blue sky.

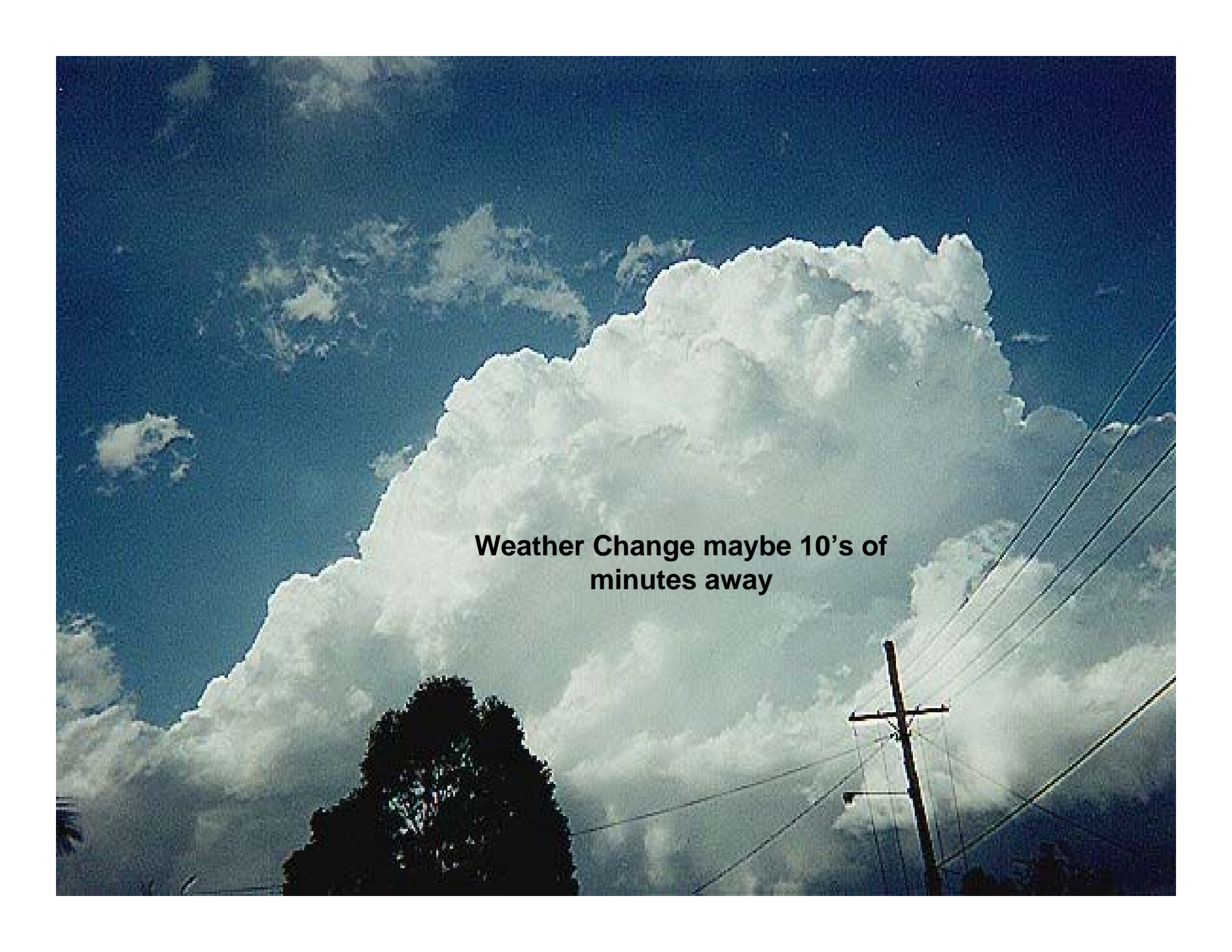
Shredded sections are called cumulus fractus.



Cumulus Congestus Clouds



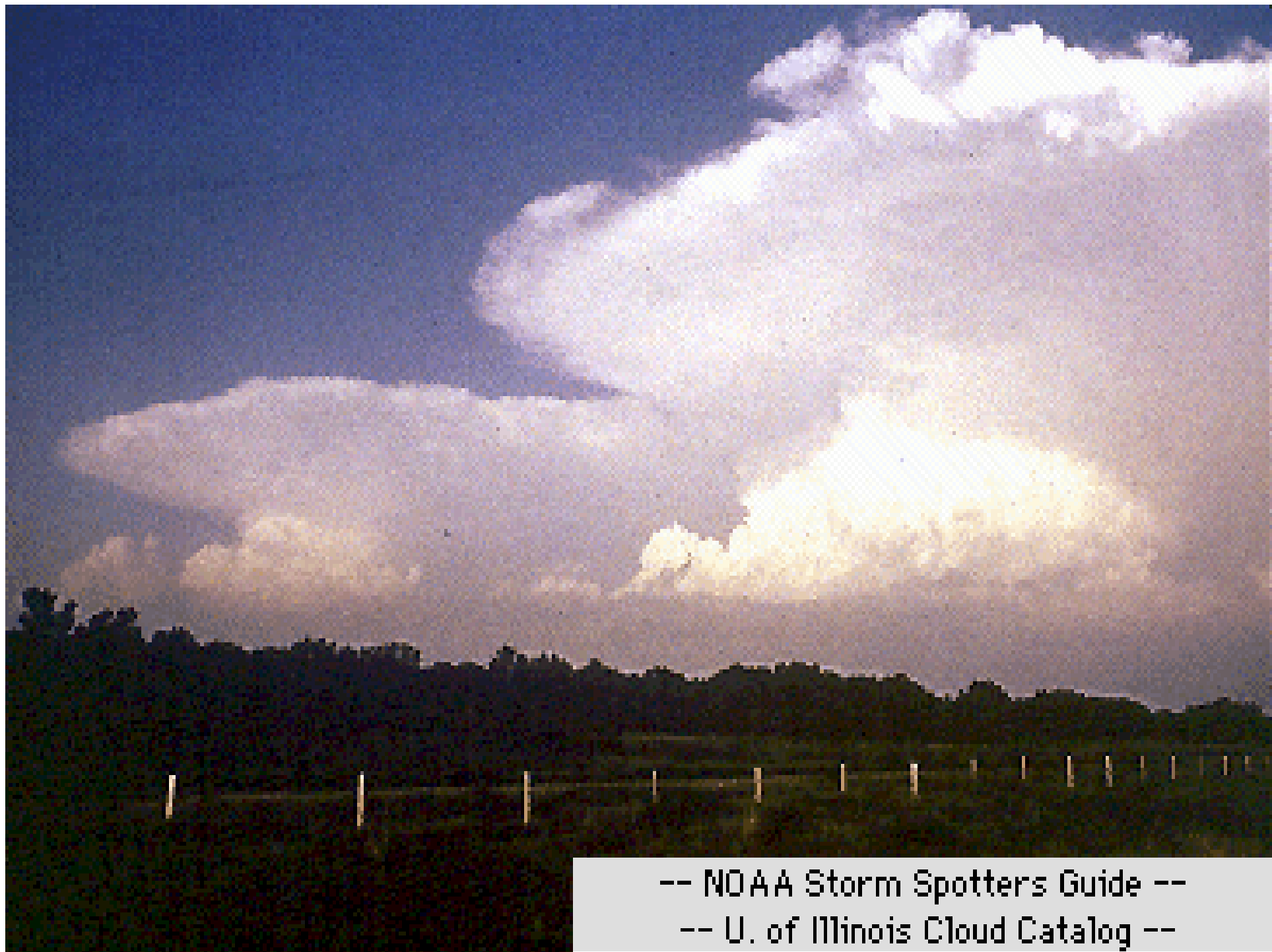
Clouds with vertical development that become larger in height, with tops taking a ragged shape similar to cauliflower. Change is certain! maybe just 1 or 2 hrs away



**Weather Change maybe 10's of
minutes away**







-- NOAA Storm Spotters Guide --
-- U. of Illinois Cloud Catalog --



Feet

Metres

18 000

5 400

15 000

4 500

12 000

3 600

9 000

2 700

6 000

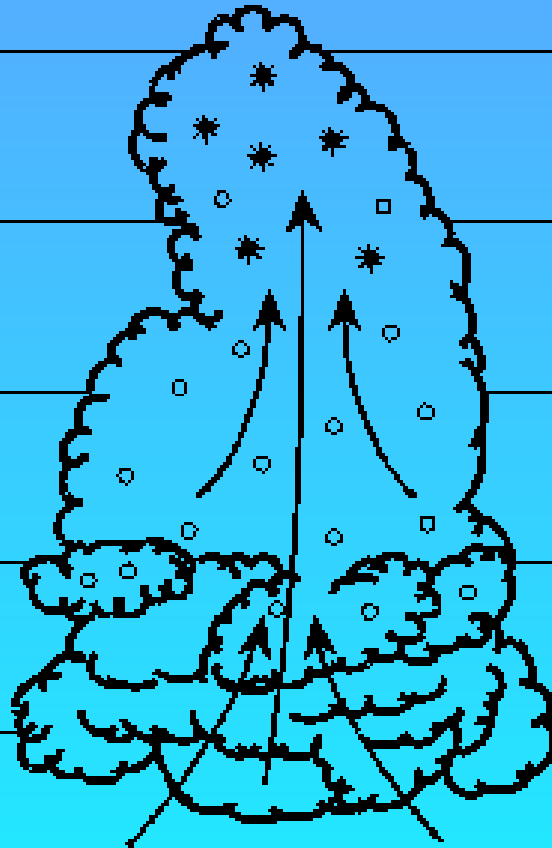
1 800

3 000

900

Surface

Surface

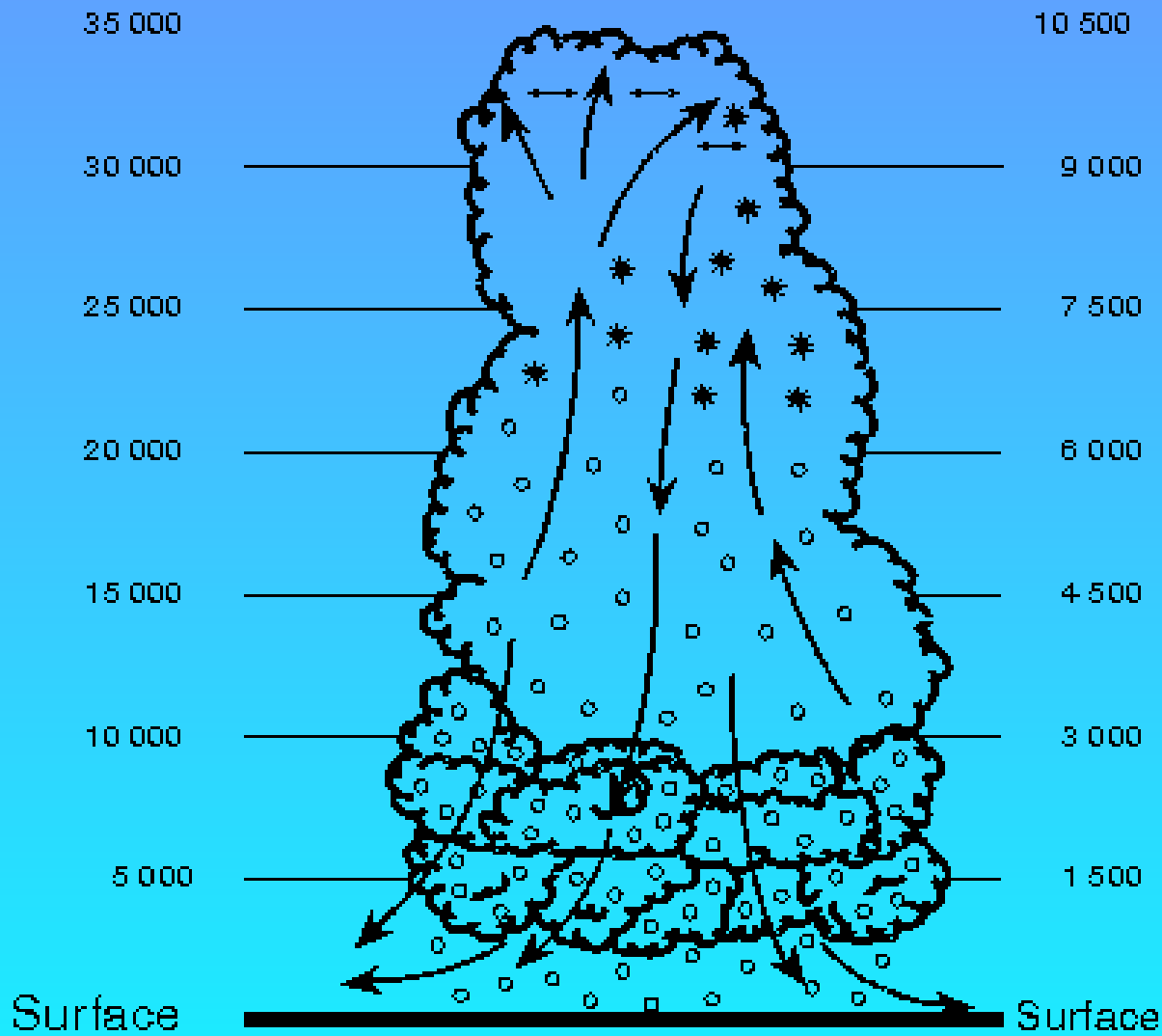


○ Water Droplets

★ Snow

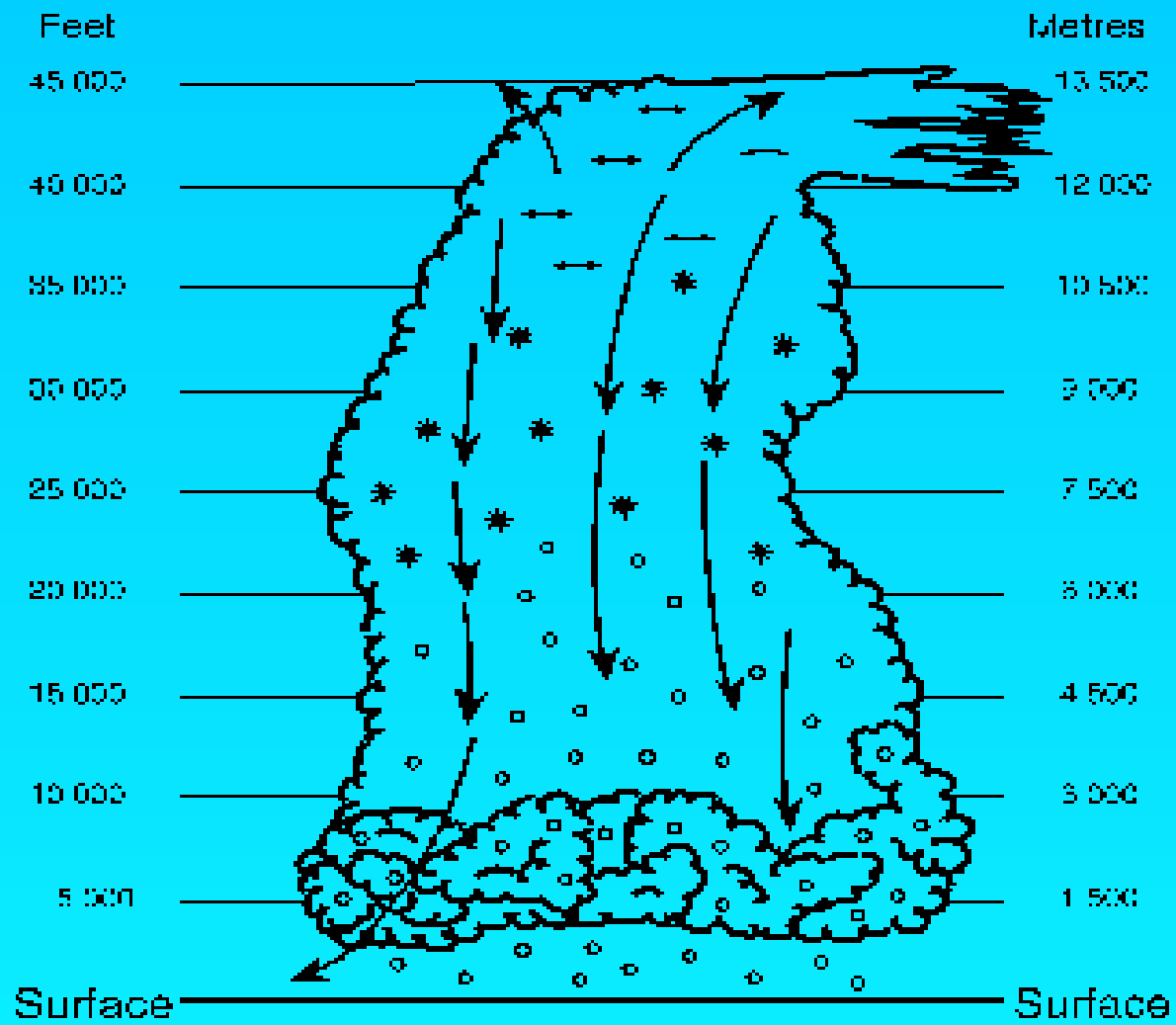
Cumulus Stage





Mature Stage

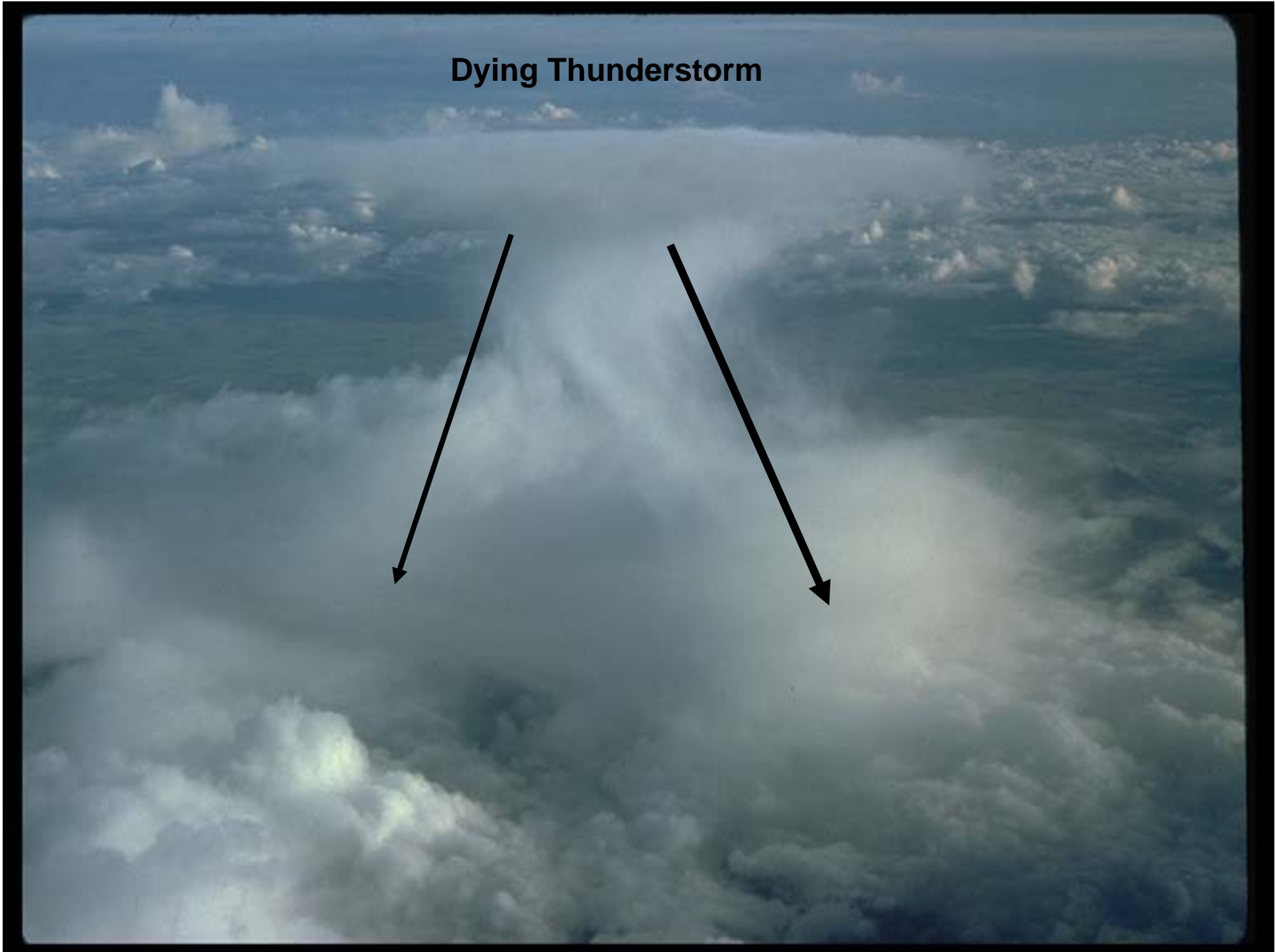




Dissipating Stage



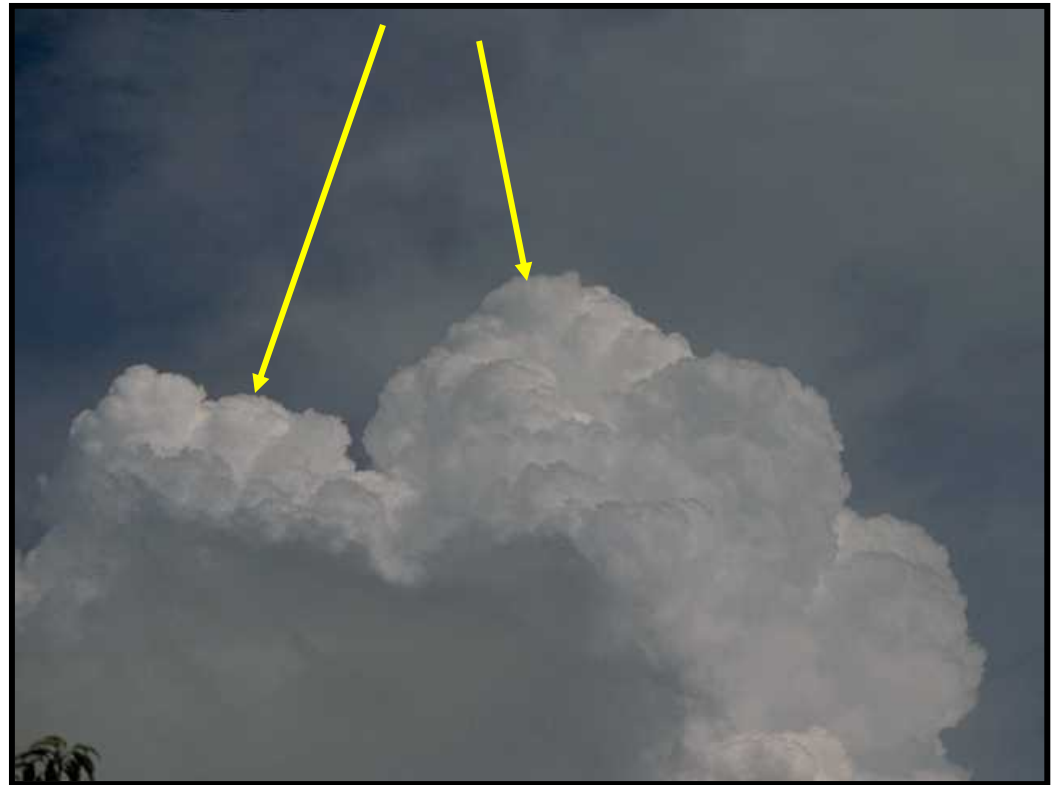
Dying Thunderstorm



Rules of Thumb for Convection

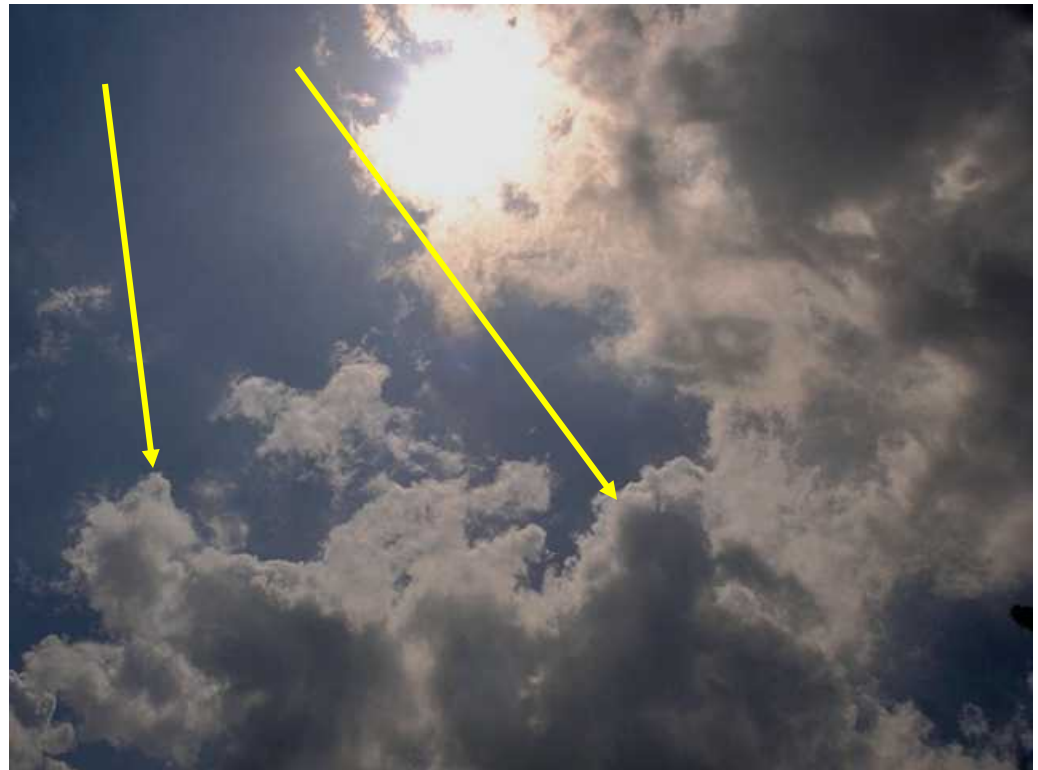
- 1

- If cumulus tops are 'crisp' and 'well defined'...
 - the cloud **will** continue to grow.



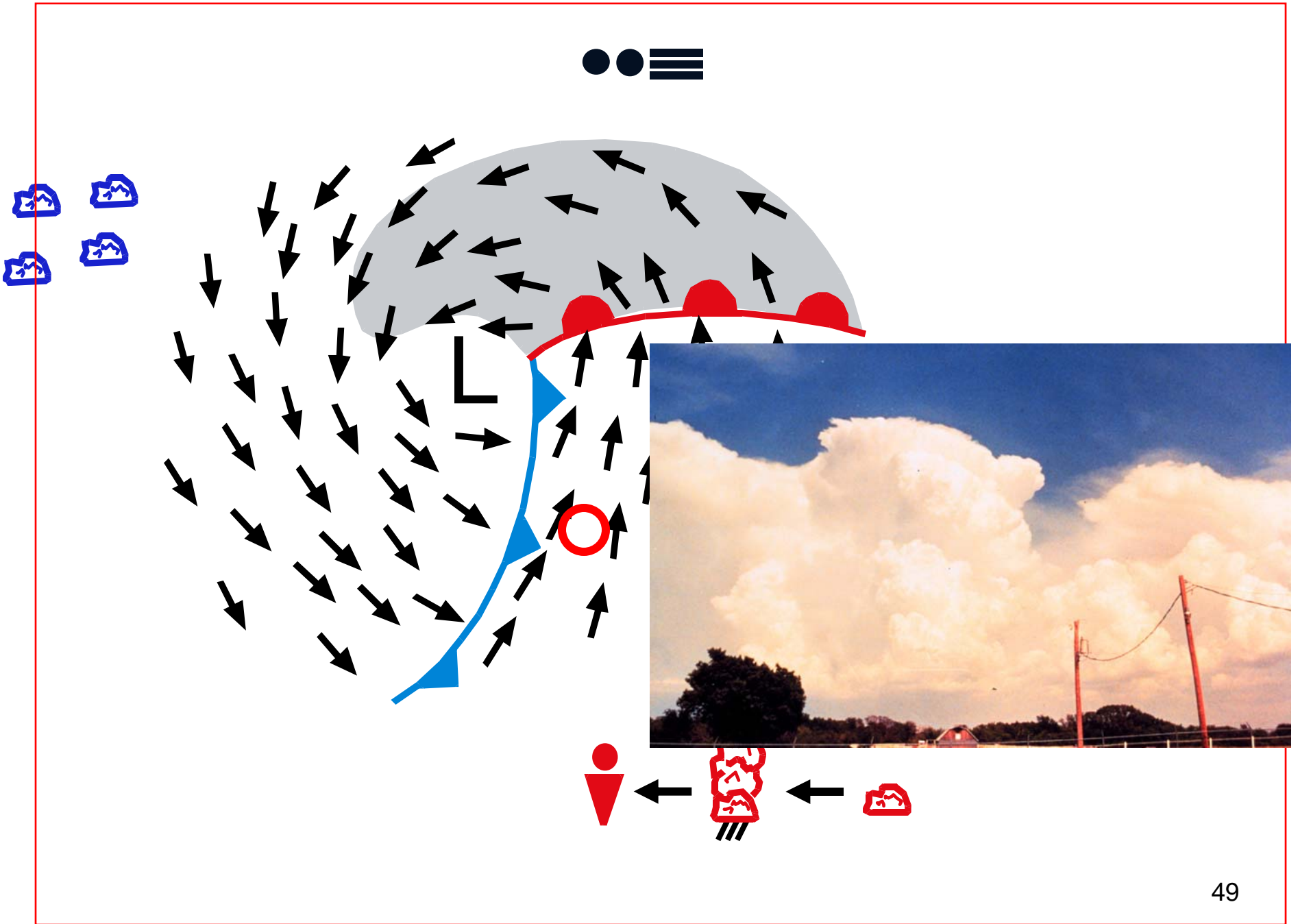
Rules of Thumb for Convection - 2

- If cumulus tops are 'ragged' and 'ill-defined'...
 - the cloud **will not** continue to grow.



Cloud Formation Leading to Severe Weather







Pileus Cloud

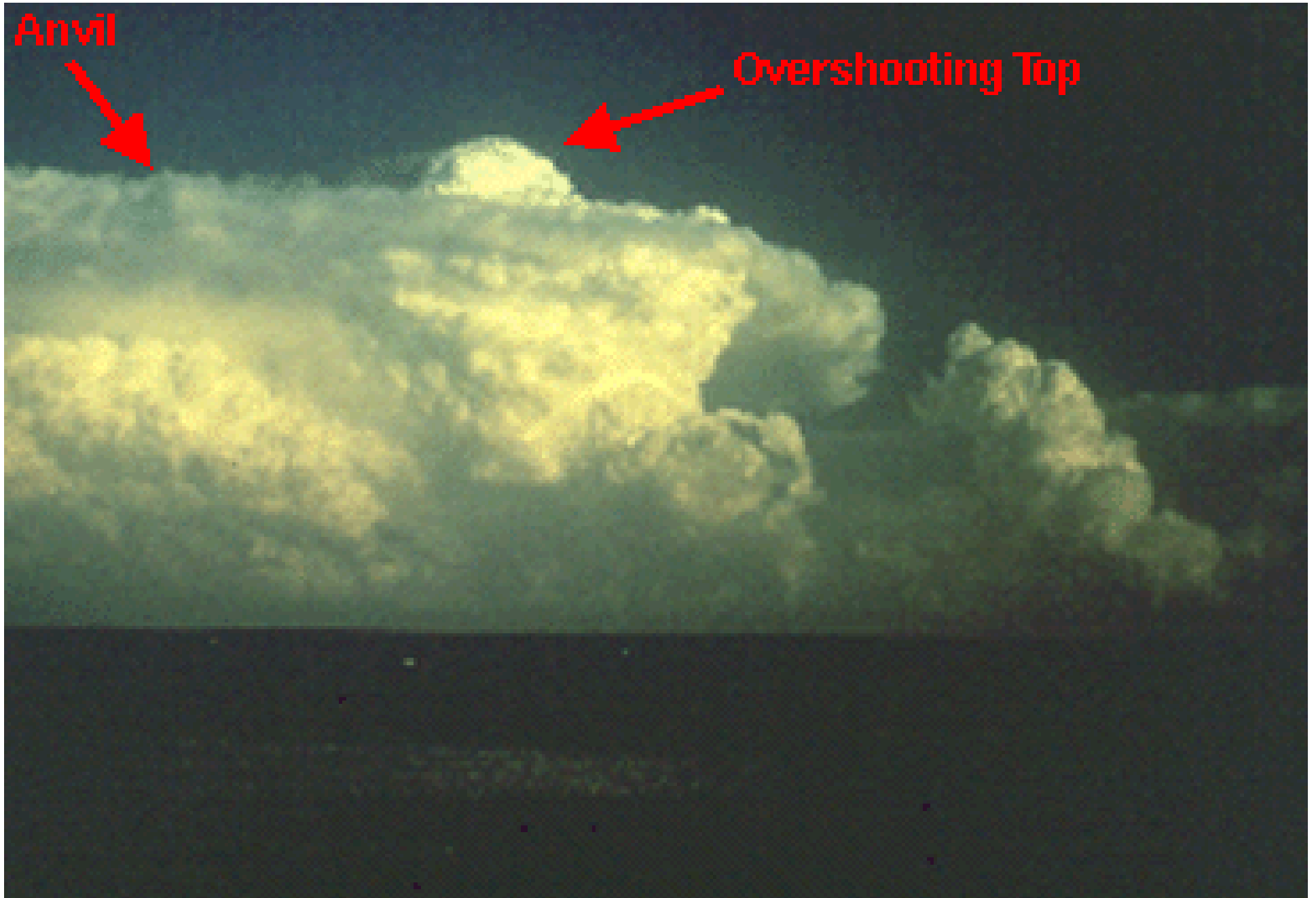


<http://australiasevereweather.com/>

<http://australiasevereweather.com/>

Anvil

Overshooting Top



Mammatus Cumulus

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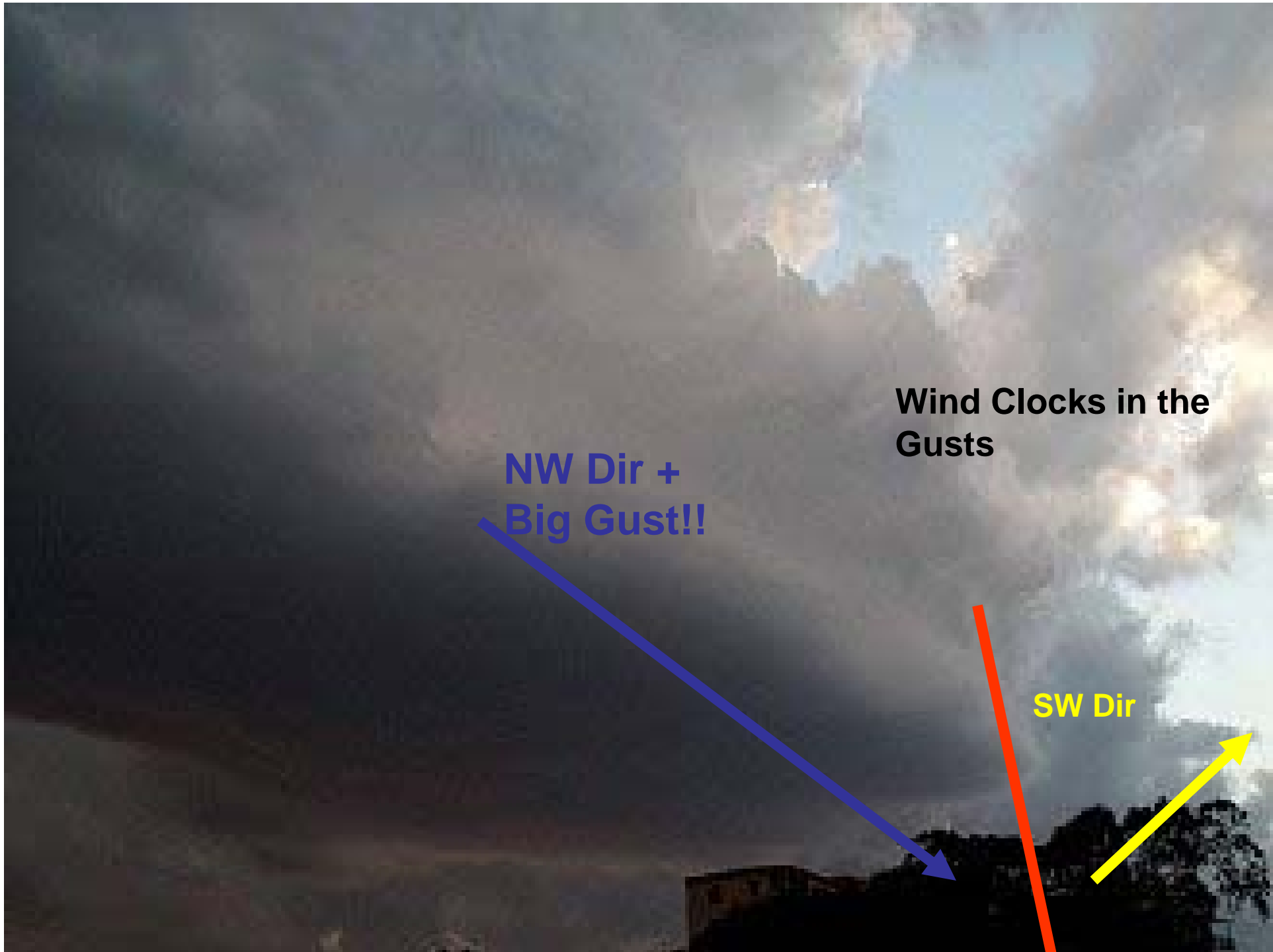
**Green and Yellow
Colouring**

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Leading edge of Gust Front

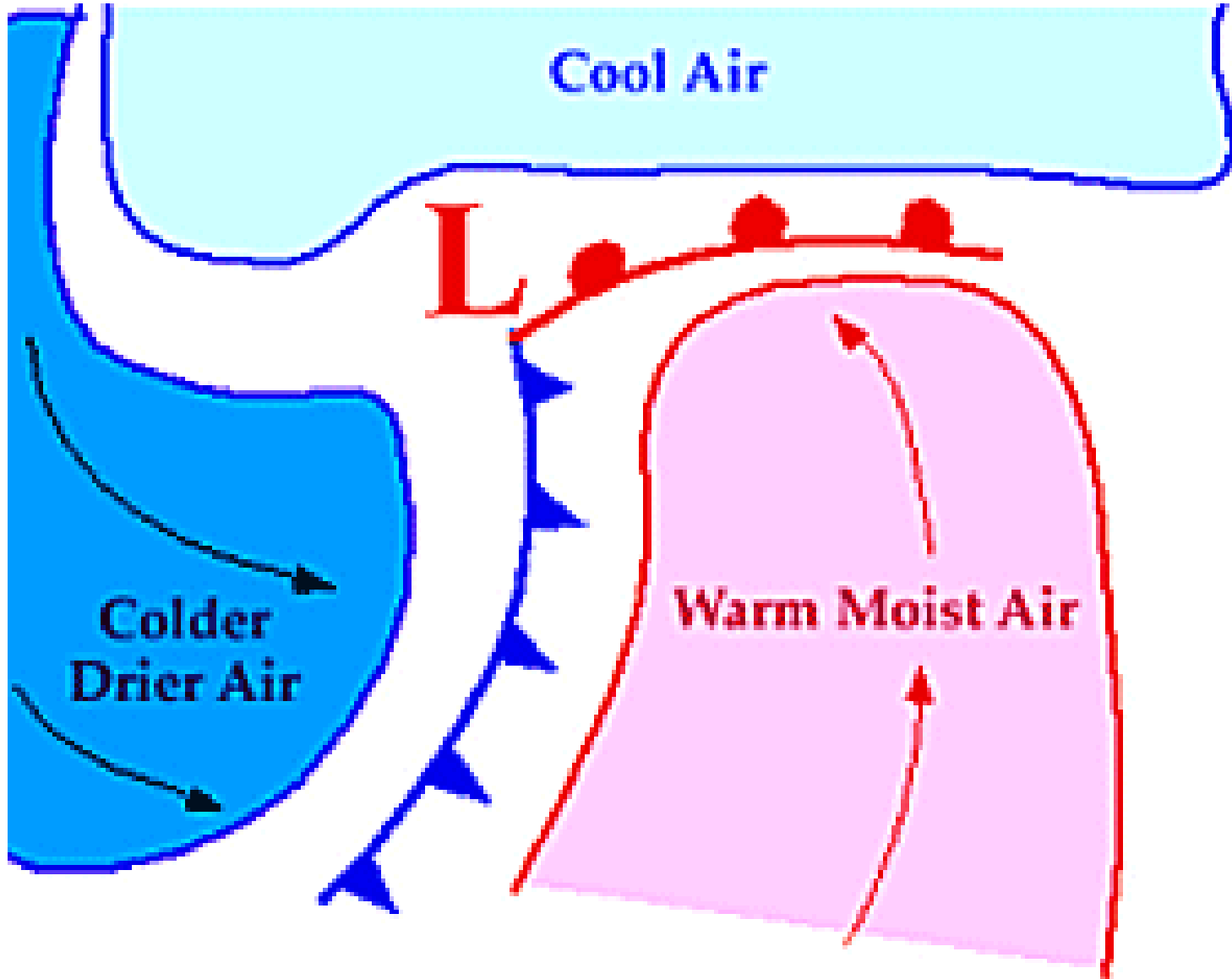
Gusts up to 50+ Knots



Wind Clocks in the Gusts

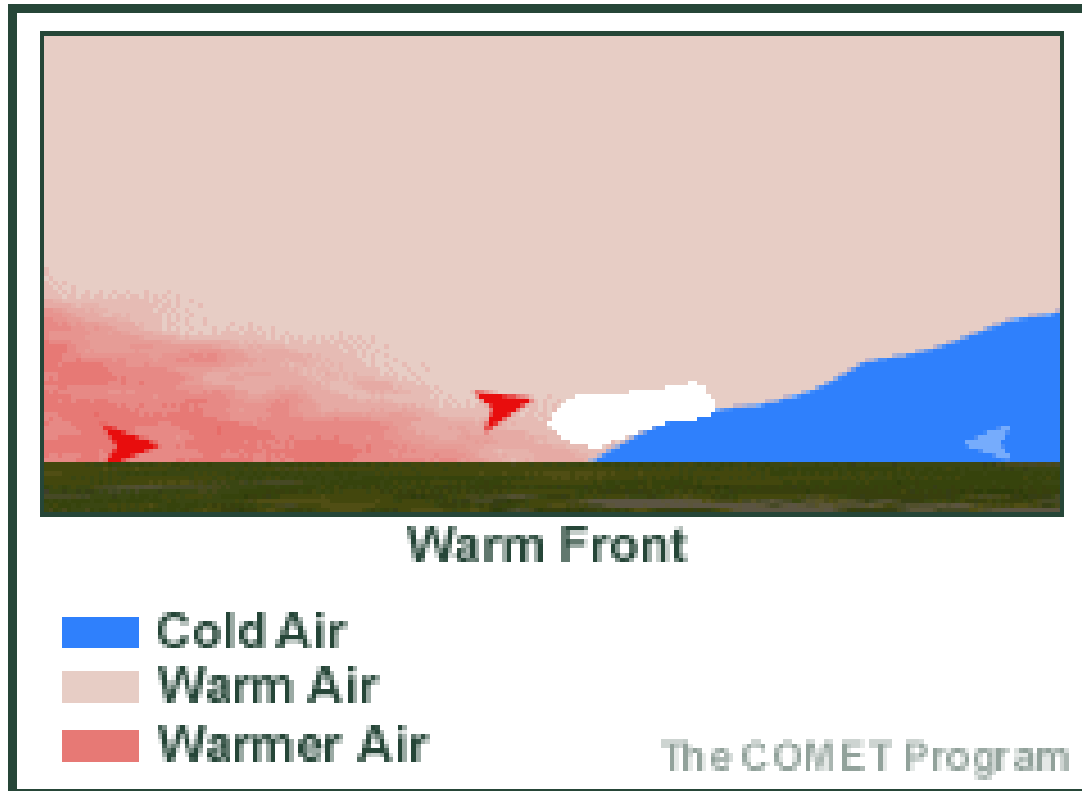
**NW Dir +
Big Gust!!**

SW Dir

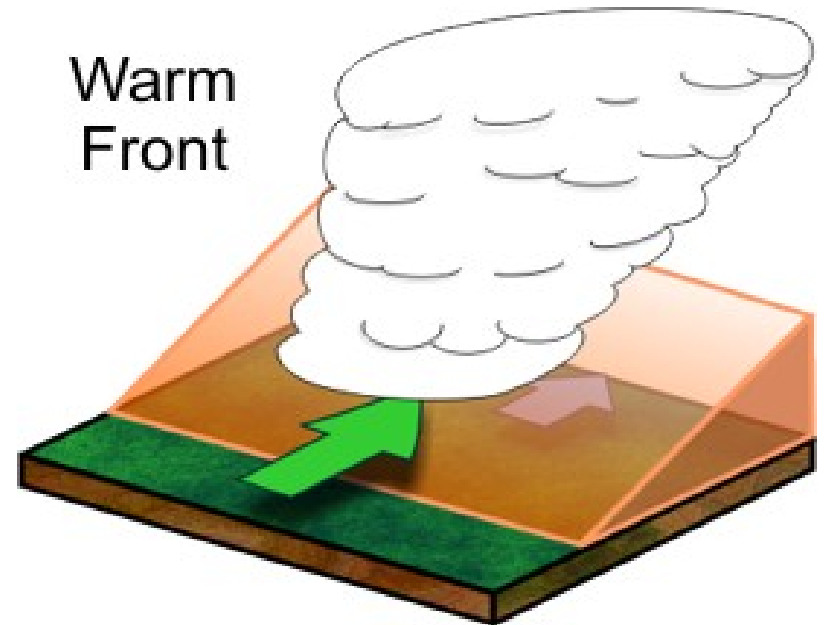


Warm Front

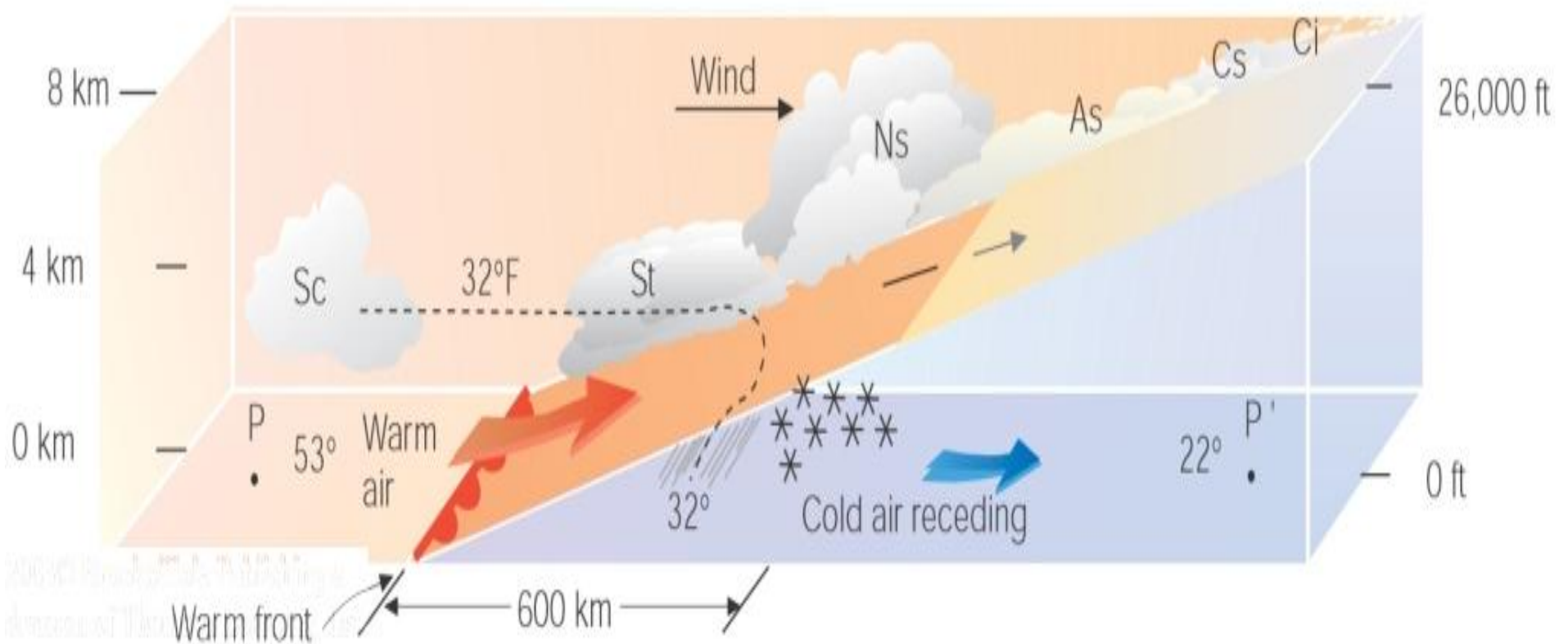
- Warm Air advancing – rides over cooler or colder air
- Usually Stable – Layer clouds develop Nimbostratus, stratus and fog – But you can get Thunderstorms
- You will have a wind shift – usually from a E or SE direction to a SW
- Pressures will fall and the level off
- Once front passes through warmer more humid (higher dew points)



Warm Front



Warm Front Transition

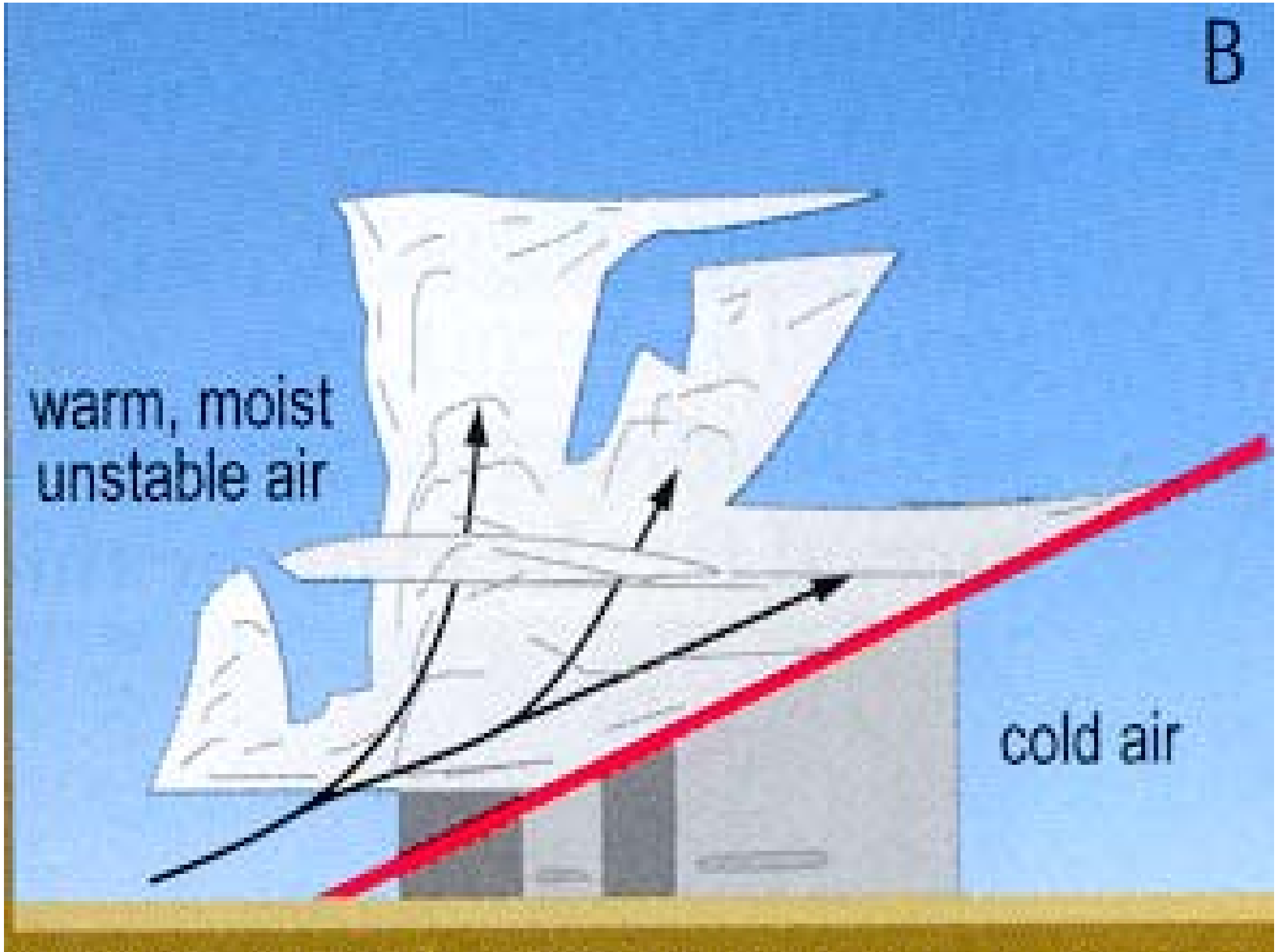


Unique clouds and precipitation patterns are associated with warm fronts, with a broader range of showers than in a cold front.

The cross-sectional view shows the gentle slope of overrunning warm air, a typical temperature inversion, and the shifting winds.

warm, moist
unstable air

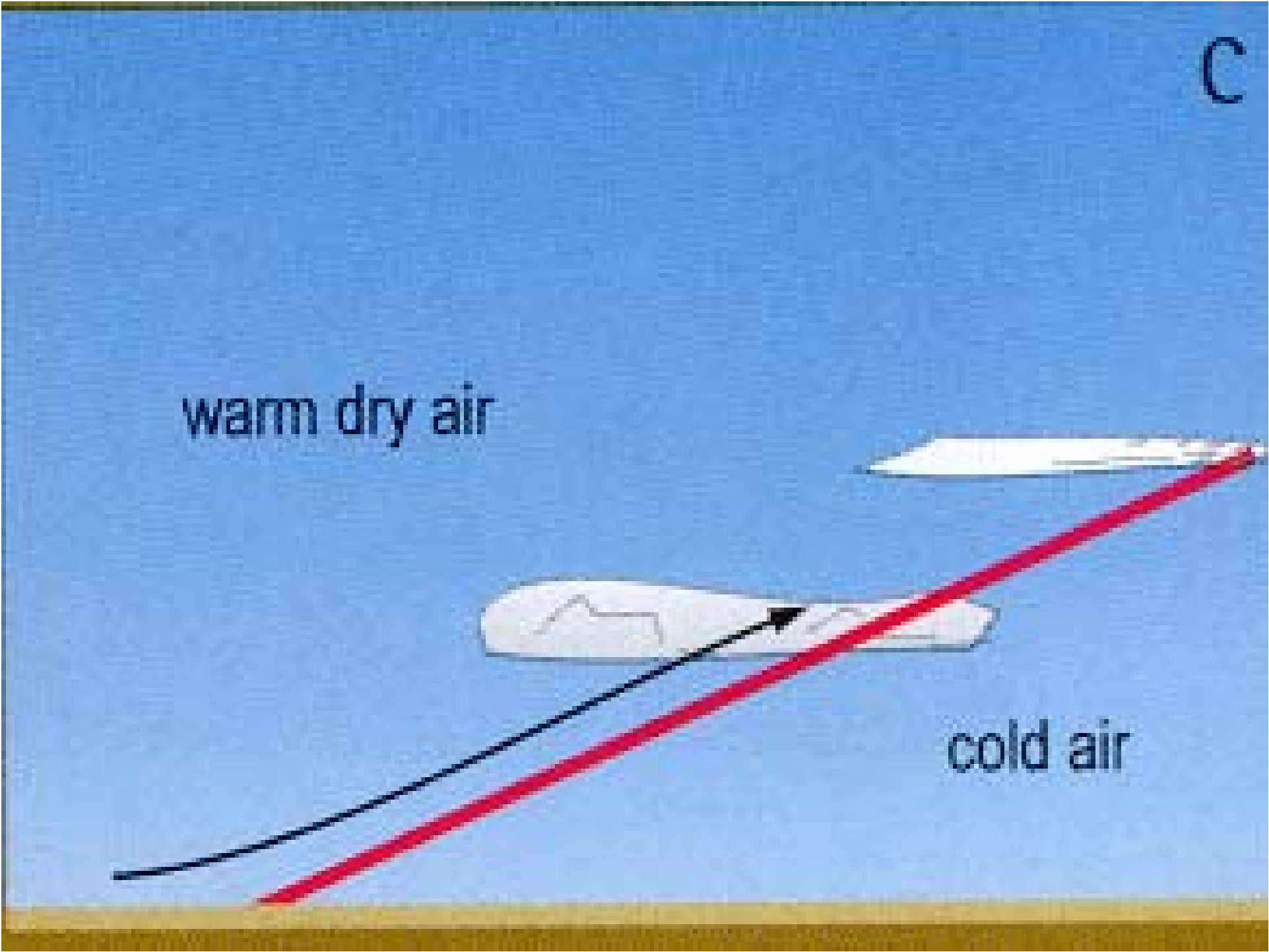
cold air

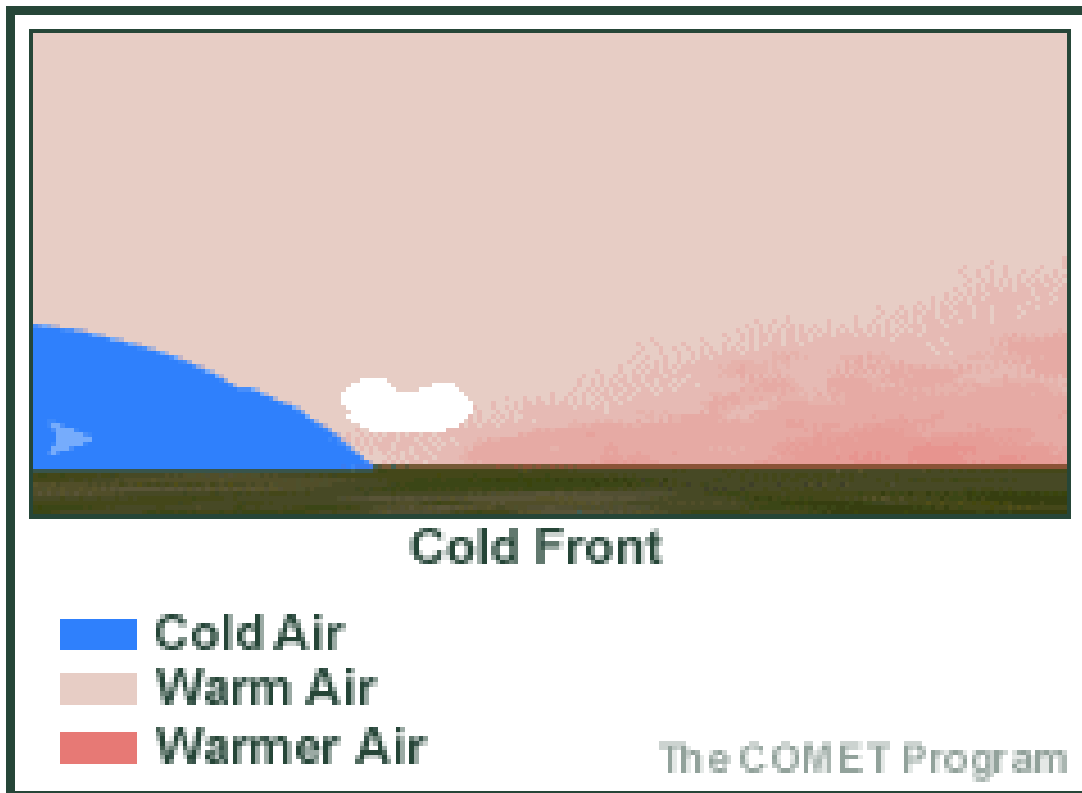


C

warm dry air

cold air





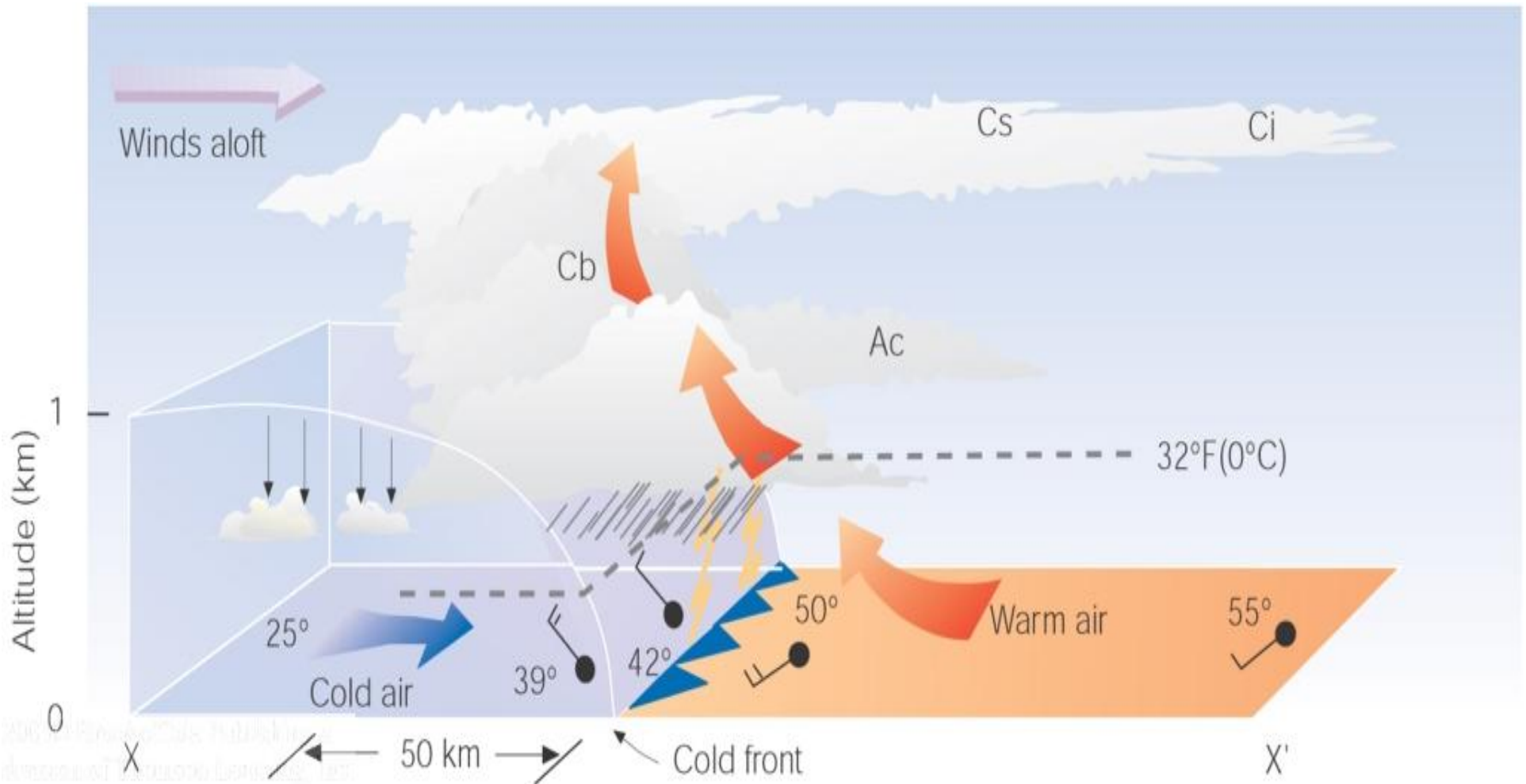
Cold Front

- Colder Drier air pushing into warmer air – more abrupt
- Usually unstable – heap type clouds develop Cumulus, TCU's CB's, Thunderstorms are a good bet
- You will have a wind shift – usually from a SW direction to a very gusty NW
- Pressures will fall with storms and rise rapidly
- Once front passes through – colder and less humid (lower dew points)



Cold Front

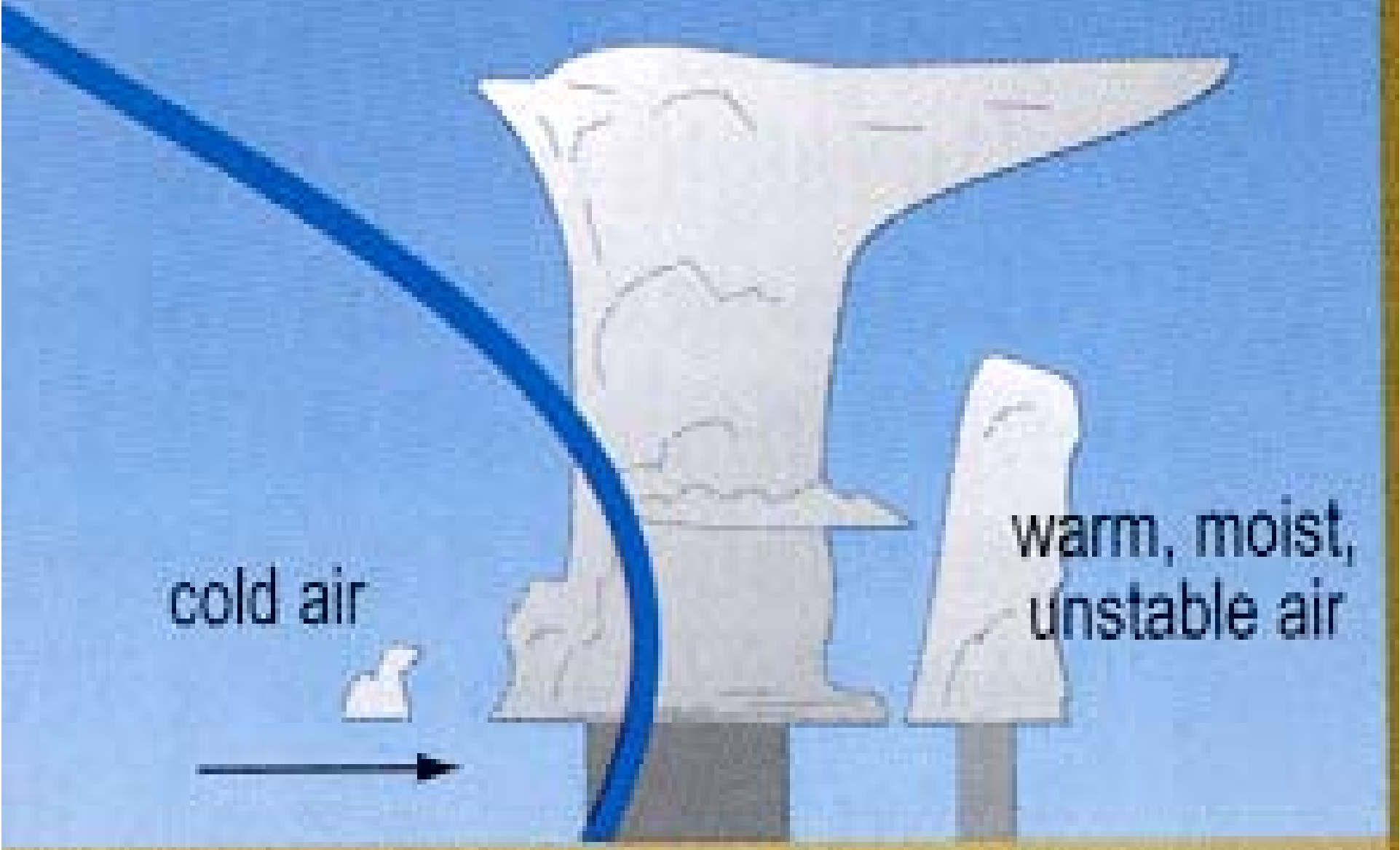
Cold Front Transition



Important cloud, wind, and temperature changes are revealed in this cross-section view of a typical cold front.

The front rises steeply (1km in 50km), and cirriform clouds protrude ahead.

A

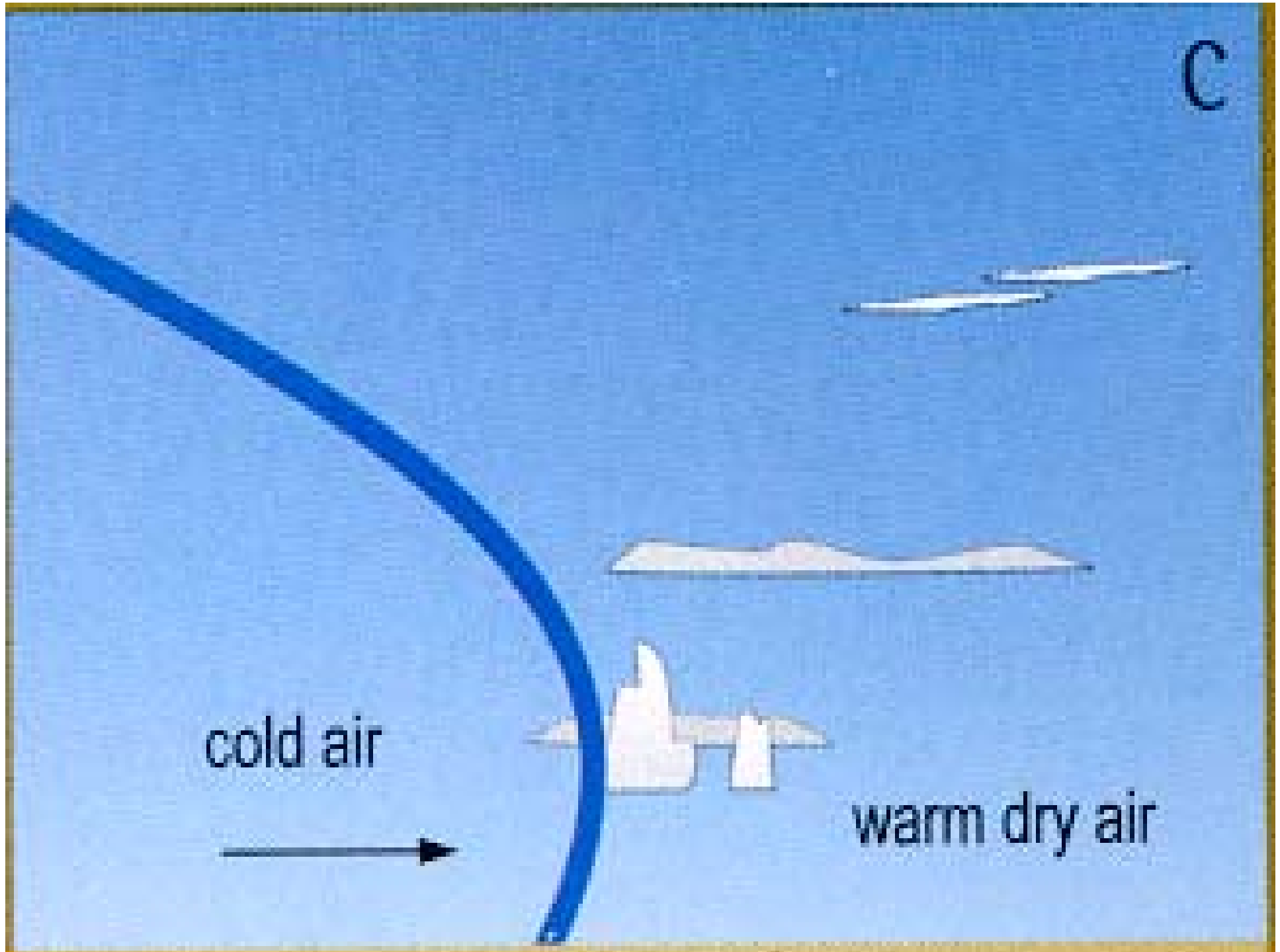


cold air

warm, moist,
unstable air

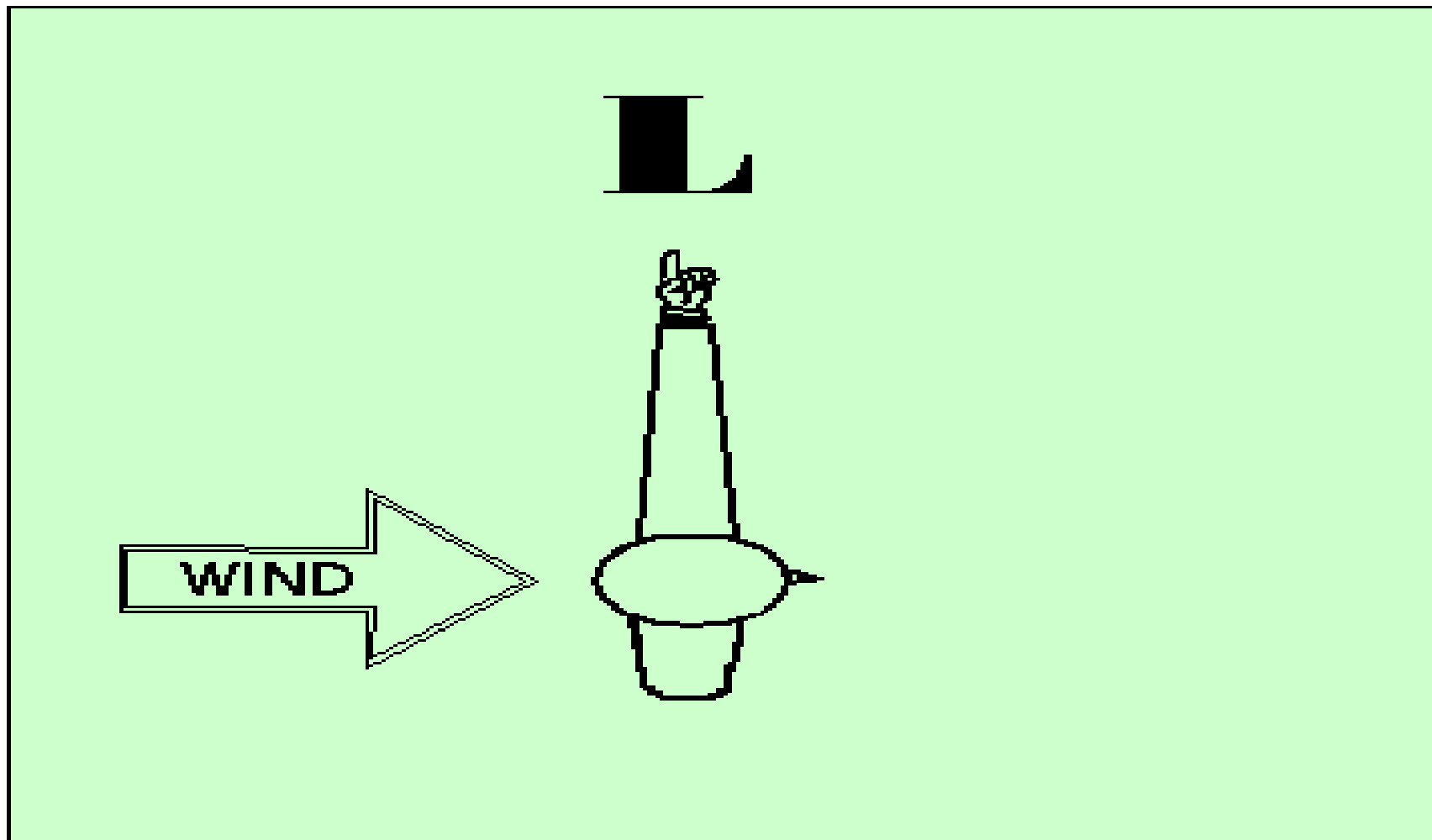


C



BUYS-BALLOT'S LAW

"When your back is to the wind, the lower pressure is on your left."





Lightning and the Mariner

Facts and myths about lightning

- The purpose of lightning protection is NOT to stop the lightning from striking. (T or F)
- Lightning grounding systems controls the “PATH” of the lightning after it hits. (T or F)
- Lightning can strike in the same place twice or more. (T or F)
- Lightning always strikes the tallest object. (T or F)
- Rubber tires protect you in a car during a lightning storm. (T or F)

What are the Chances of Lightning Striking Your Boat?

The following statistics are based on all of the BoatUS Marine Insurance claims for lightning damage over a five-year period.

Auxiliary Sail .6% Six out of 1000

Multi-hull sail .5% Five out of 1000

Trawlers .3% Three out of 1000

Sail Only .2% Two out of 1000

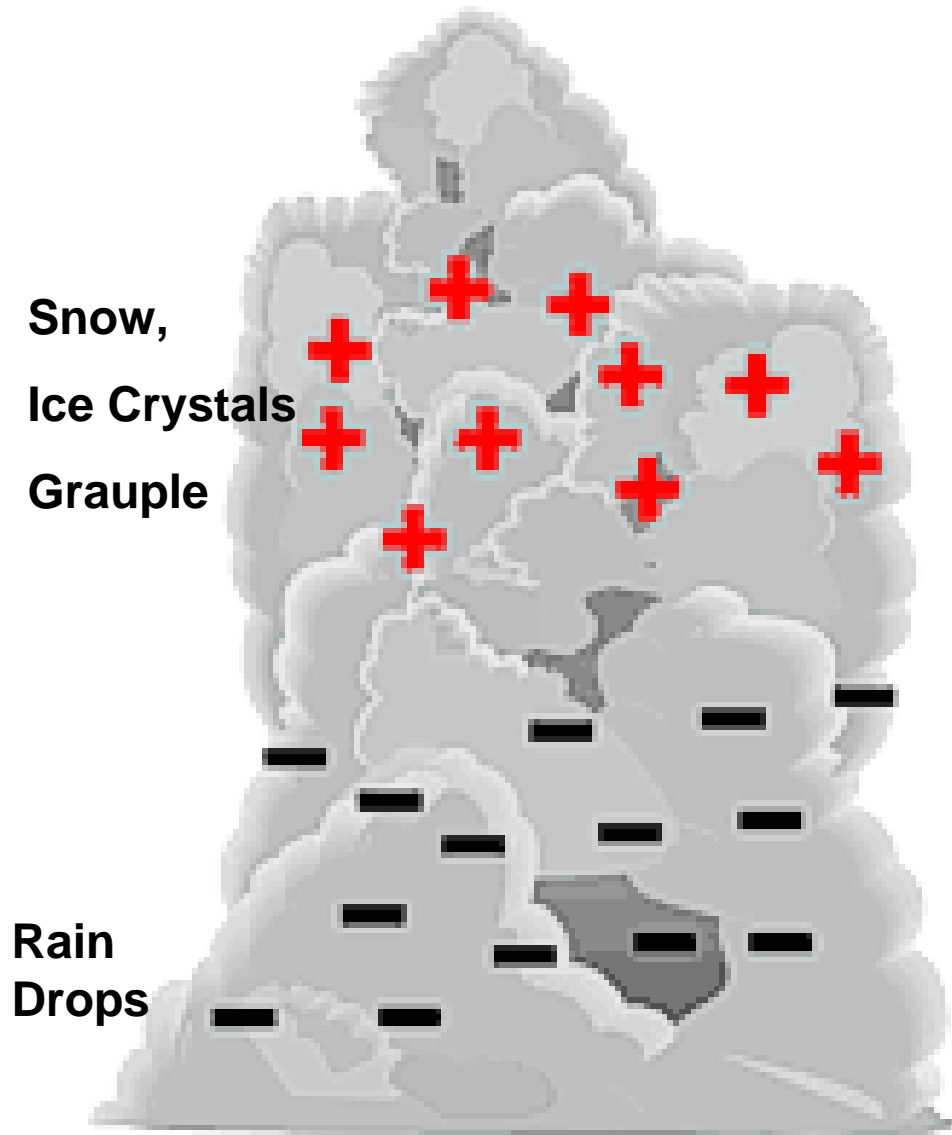
Cruisers .1% One out of 1000

Runabouts .02% Two out of 10,000

Source: BoatUS Marine Insurance Claim Files

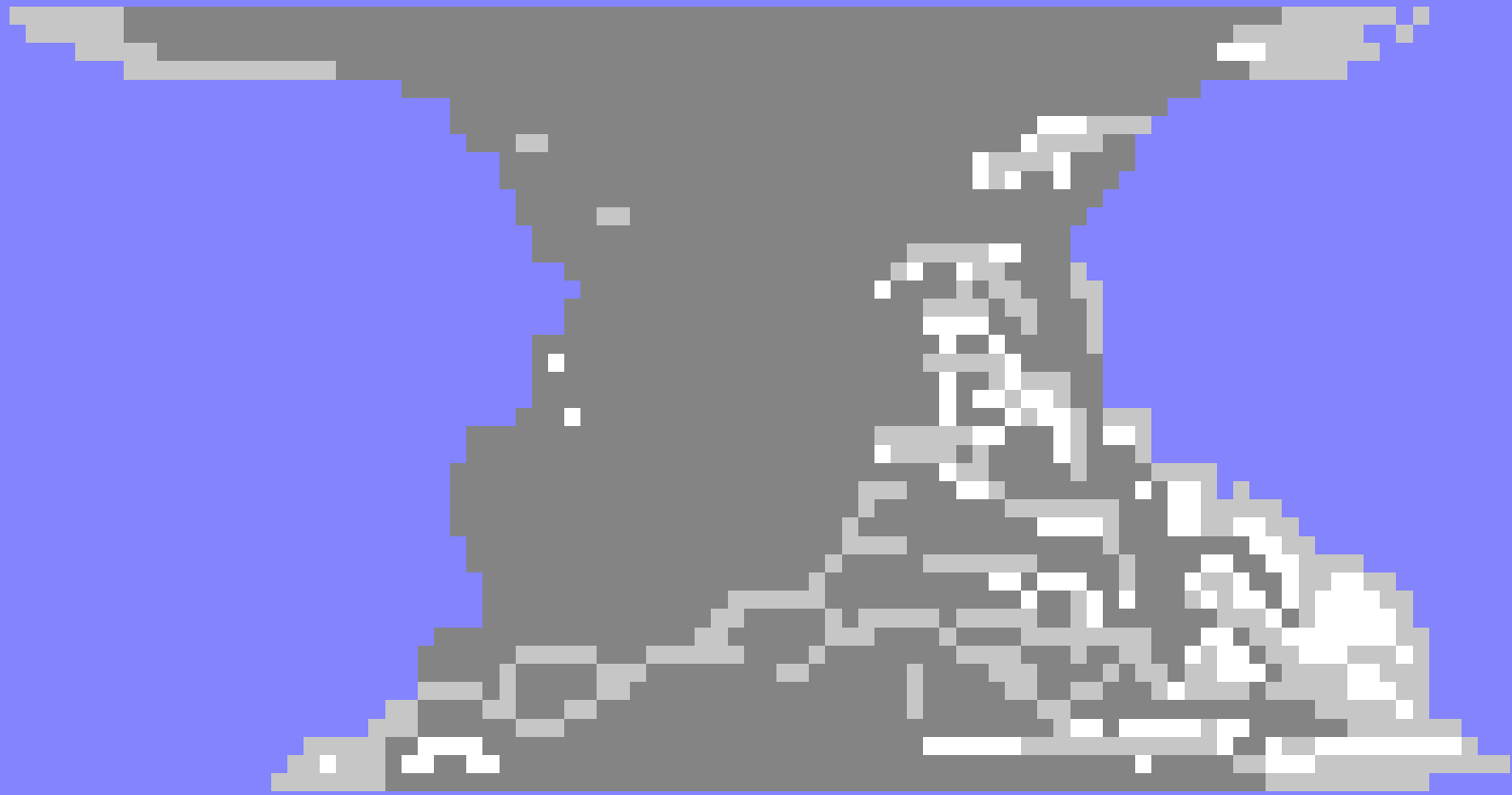
****General Population 1 in 14.5 Million****

**Electric charge leaking
from her head**

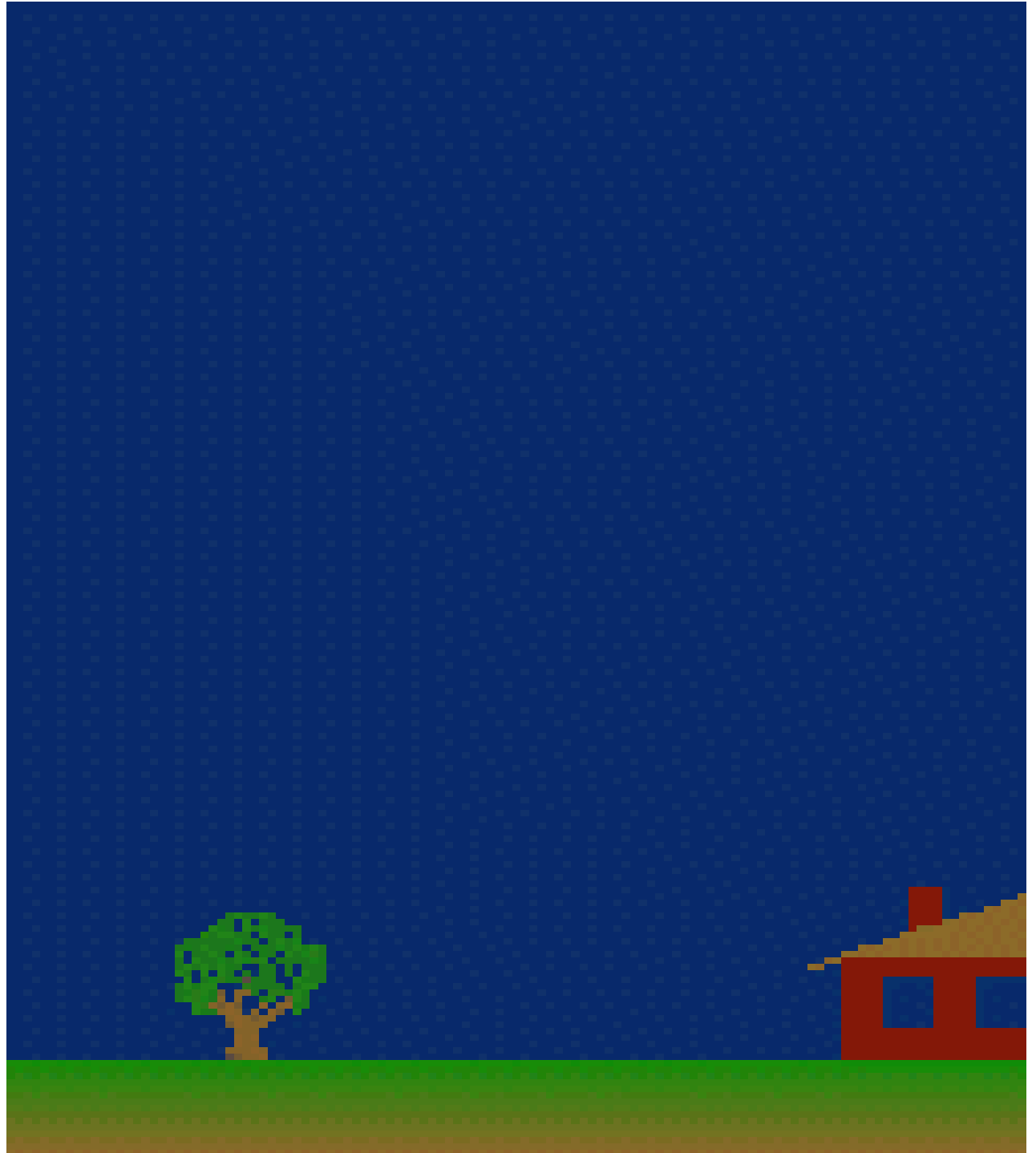


**Snow,
Ice Crystals
Grauple**

**Rain
Drops**



Anatomy of a Strike



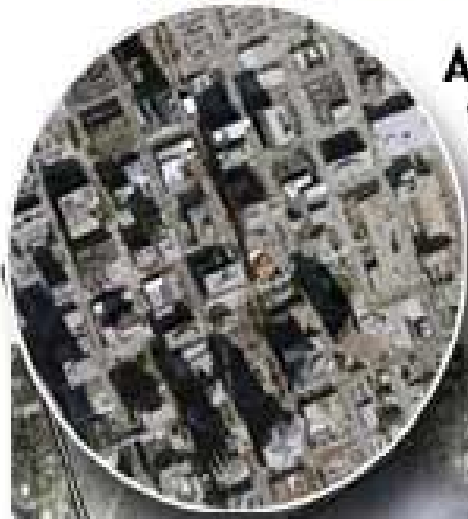




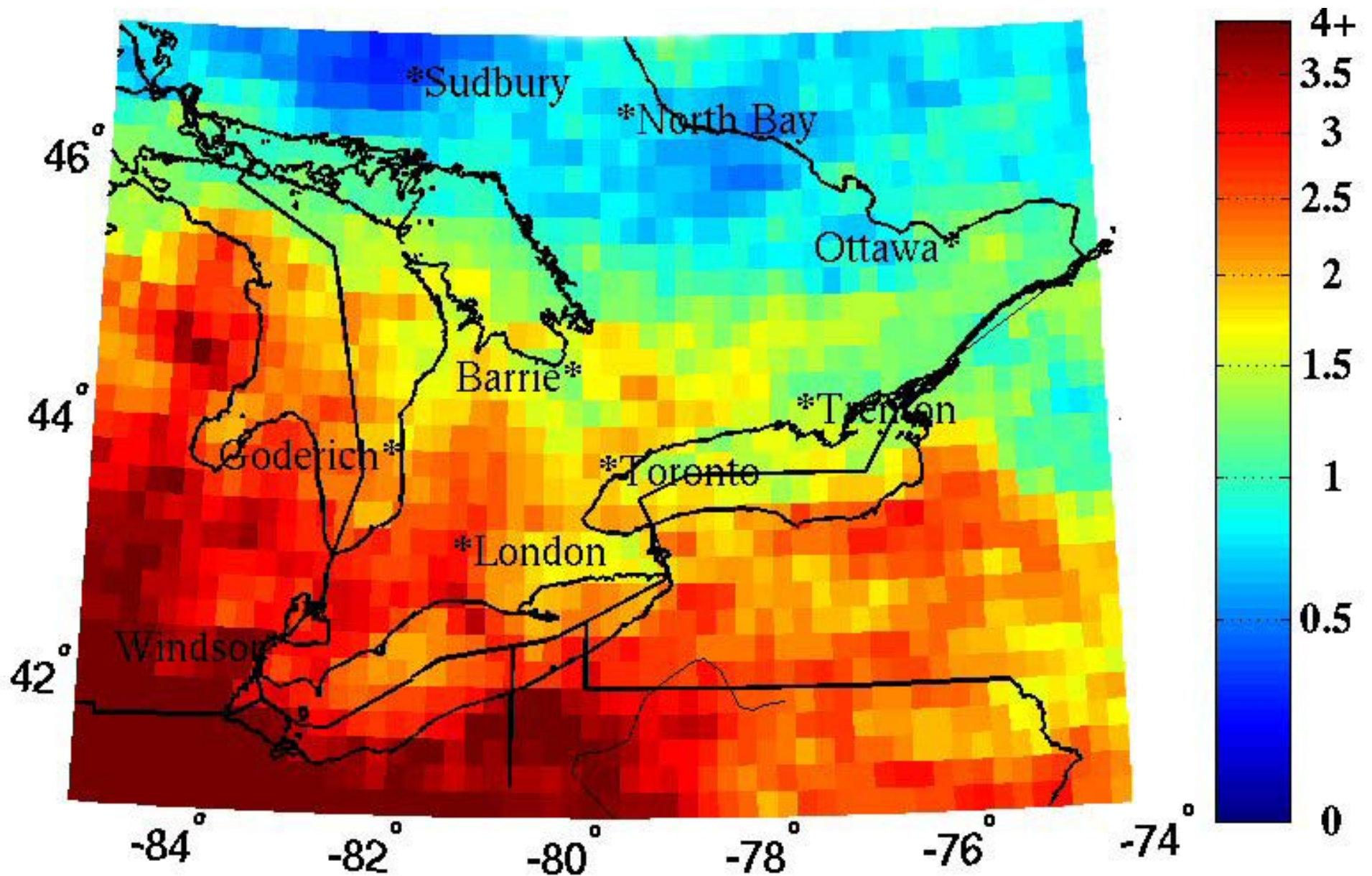
A BOLT OUT OF THE BLUE

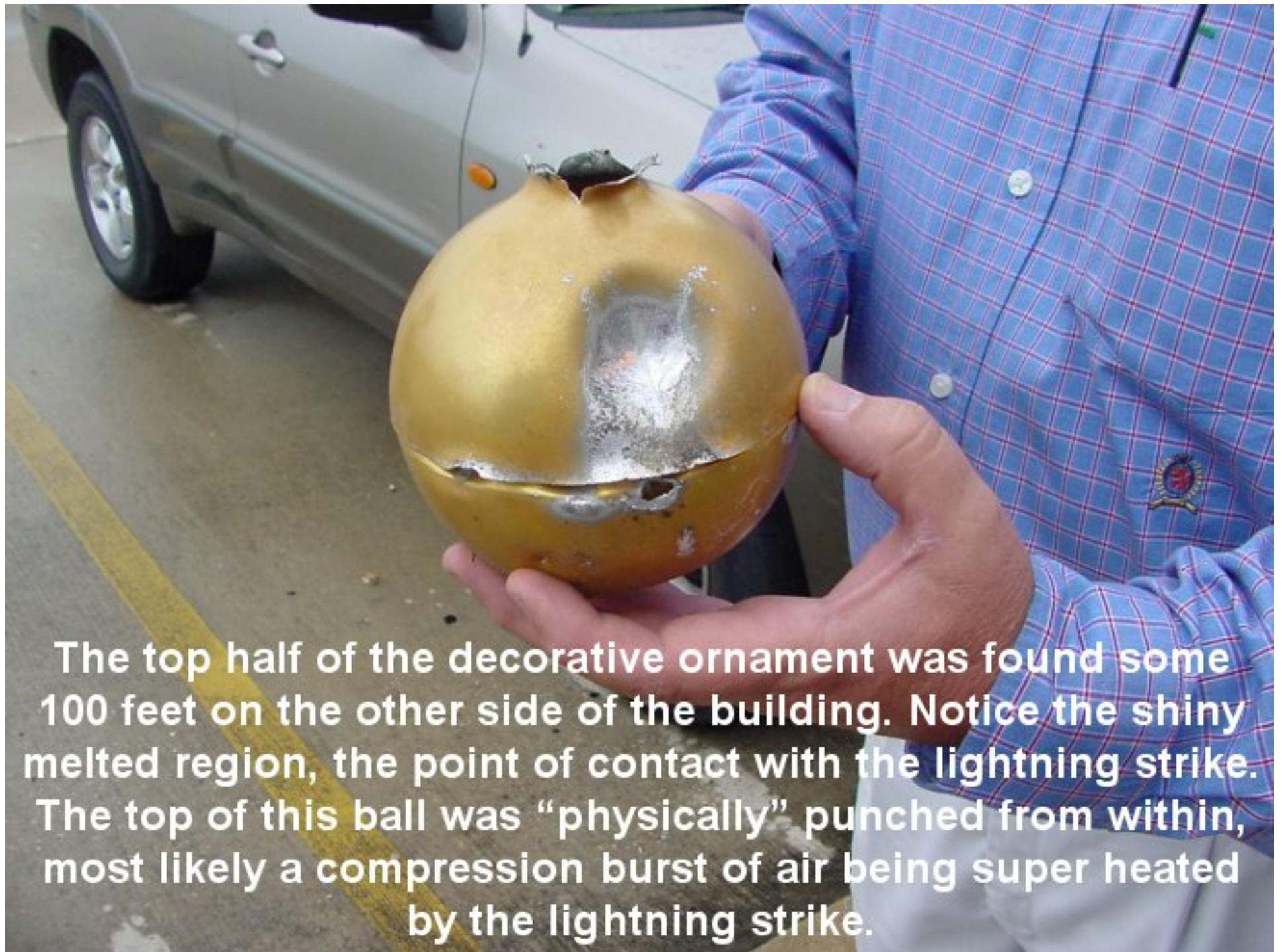
A storm cloud over Tampa...

...can send a lightning bolt into a sunny suburban baseball field complex 8 miles away.



Lightning Climatology for Southern Ontario





The top half of the decorative ornament was found some 100 feet on the other side of the building. Notice the shiny melted region, the point of contact with the lightning strike. The top of this ball was “physically” punched from within, most likely a compression burst of air being super heated by the lightning strike.







THUNDER

Thunder is the acoustic shock wave caused by the extreme heat generated by a lightning flash.

- The air is instantaneously heated to as much as 50,000 F (~28,000 C), *five times* the surface of the sun!
- Its expansion rate exceeds the speed of sound, and a sonic boom (thunder) results.

Learn the “30-30 rule”

- Take appropriate shelter when you can count 30 seconds or less between lightning and thunder.
- Remain sheltered for 30 minutes after the last thunder.
- New Rule *“When Thunder Roars – Go Indoors!”*

What to do if you are outside

1. Seek shelter in a truck, car, or van.
2. Stay 15 feet away from other people to avoid transfer of shock.
3. Stay away from trees, picnic shelters or rain shelters, and canopies.
4. Hide in ditches or places of lower levels, but try to avoid water
5. If this is not an option, crouch down with your feet together and cover your ears to protect them from the thunder.





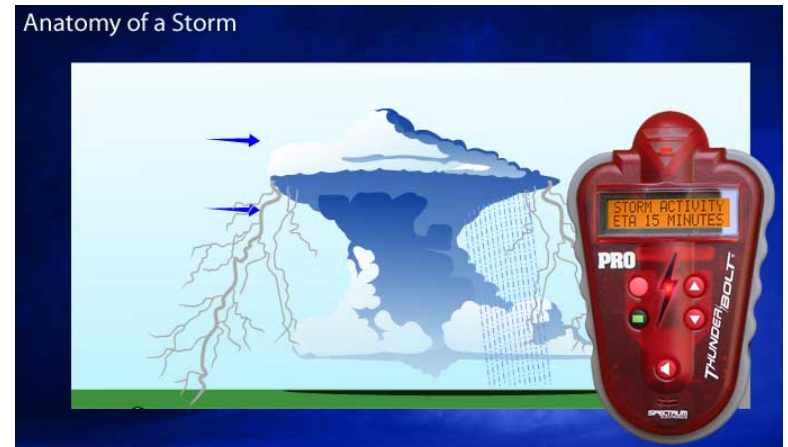
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Questions?

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